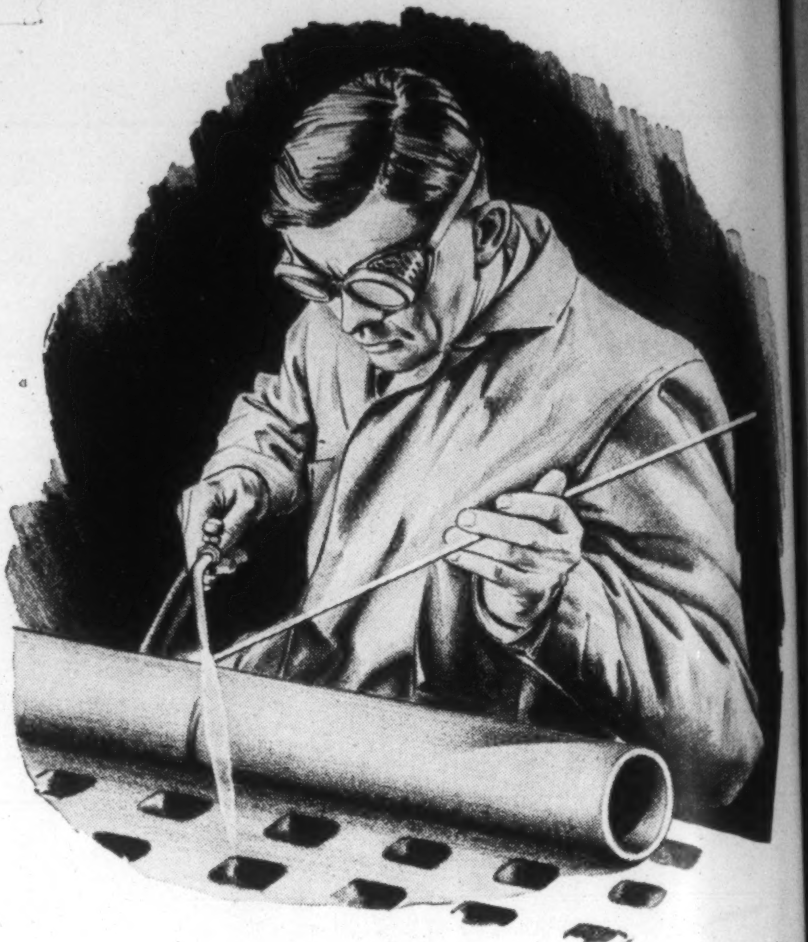
ENGINEERING MAGAZINE OF THE METAL-WORKING INDUSTRIES

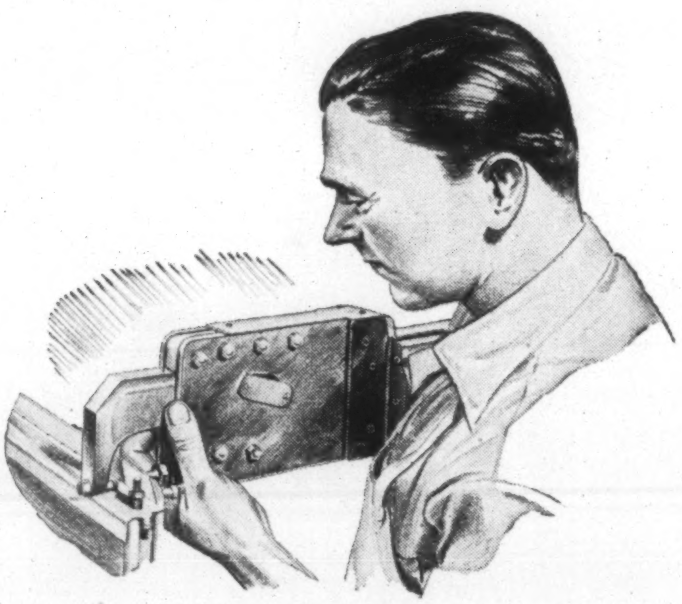
# METALS and ALLOYS

EAST ENGINEERING
LIBRARY

[illegible]



# Magnesium alloys are easily joined by every common method



## Riveting—gas, arc, spot and flash welding all do the job

Matchless lightness has earned for magnesium an industry-wide reputation. It's when you come to build this lightness into your product that you first fully appreciate magnesium's many important fabrication advantages.

Easy joining is a major one. Magnesium readily lends itself to every joining method in common use, including riveting and gas, arc, spot, and flash welding. Procedures are very similar to those employed with other metals.

Riveting is the method most widely used for joining magnesium sheet and extrusions, and various Dowmetal Magnesium Alloys in these forms—as well as sand castings—can also be gas and arc welded. Spot and flash welding each serve definite fabrication requirements.

Dow has taken active part in the development of these techniques, and the resultant data is now available to you. The nearest Dow office will give you technical assistance in the best procedures to use in your own product.

**DOWMETAL**

*magnesium*

**THE METAL OF MOTION**

MAGNESIUM DIVISION, THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN
New York • Boston • Philadelphia • Washington • Cleveland • Detroit • Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle

FRED P. PETERS, Editor-in-Chief

EDWIN F. CONE, Consulting Editor

HAROLD A. KNIGHT, News Editor
KENNETH ROSE, Engineering Editor
DORIS M. BARRY, Assistant Editor
ELEANOR M. WOLFE, Assistant Editor
FRANK J. ARMEIT, Production
JOHN CIAMPI, Art
EDWIN L. CADY, Contributing Editor
GERALD E. STEDMAN, Contributing Editor

On leave with the Armed Forces
ROBERT S. BURPO, Jr., Lt. (j.g.) EV (S), U.S.N.R.
HENRY R. CLAUSER, Lt., Ord. Dept., A.U.S.

PHILIP H. HUBBARD
Vice-President and Publishing Director

WILLIAM P. WINSOR
Vice-President and Business Manager

JOHN ZELLNER
Circulation Manager

**Advisory Board**

H. A. ANDERSON, Western Electric Co.
WILLIAM BLUM, Bureau of Standards
A. L. BOEGEHOLD, General Motors Corp.
P. H. BRACE, Westinghouse Electric & Mfg. Co.
G. H. CLAMER, Ajax Metal Company
JUNIUS D. EDWARDS, Aluminum Co. of America
O. W. ELLIS, Ontario Research Foundation
H. J. FRENCH, International Nickel Co., Inc.
JOHN HOWE HALL, General Steel Castings Corp.
S. L. HOYT, Battelle Memorial Institute
J. B. JOHNSON, Army Air Forces, Materiel Command
JOHN JOHNSTON, United States Steel Corp.
JAMES T. MacKENZIE, American Cast Iron Pipe Co.
R. F. MEHL, Carnegie Institute of Technology
W. B. PRICE, Scovill Manufacturing Co.
LEO F. REINARTZ, American Rolling Mill Co.
H. A. SCHWARTZ, Nat'l Malleable & Steel Castings Co.
F. N. SPELLER, Consulting Metallurgical Engineer
JEROME STRAUSS, Vanadium Corp. of America

Published Monthly by Reinhold Publishing Corporation, 330 West 42nd St., New York (18), N. Y., U.S.A. Ralph Reinhold, President and Treasurer; H. Burton Lowe, Vice President and Secretary; Philip H. Hubbard, Vice President; Francis M. Turner, Vice President; William P. Winsor, Vice President; G. E. Cochran, Vice President. Price 25 cents a copy. Annual Subscription: U. S., Possessions and Canada, $2.00. All Other Countries, $3.00. (Remit by New York Draft.) Copyright, 1945, by Reinhold Publishing Corporation. All rights reserved. Entered as second class matter Aug. 16, 1944, at the Post Office at New York, N. Y., under the Act of March 3, 1879.

# METALS and ALLOYS

**The Engineering Magazine of the Metal-Working Industries**

VOLUME 21 • NUMBER 5 • MAY, 1945

## This Month

*Integrated Materials and Methods Control* — 1302
GERALD E. STEDMAN

*Blackened Stainless Steels* — 1309
PERRY B. STRASSBURGER

*Flame Cutting and Machining Methods* — 1313
EDWIN LAIRD CADY

*Electrical Contacts* — 1318
C. B. GWYN, JR.

*Vacuum Casting of Electronic Parts* — 1324
KENNETH ROSE

*Sea-Air Corrosion of Magnesium Alloys* — 1327
J. A. PELOUBET

*HEAT TREATMENT OF STEEL* — 1335
*"Materials and Methods Manual" No. 6*

*ENGINEERING FILE FACTS*

*No. 80—High Strength Cast Irons* — 1355
*No. 81—Glass, an Industrial Material* — 1359

## Every Month

*The Production Front* — 1227
*Editorials* — 1297
*Letter to the Editor* — 1334
*Shop Notes* — 1363
*Engineering Digest* — 1371
*Book Reviews* — 1438
*Manufacturers' Literature* — 1441
*News* — 1449
*Advertisers and Their Agencies* — 1532
*Blueprints* — 1534

## Next Month

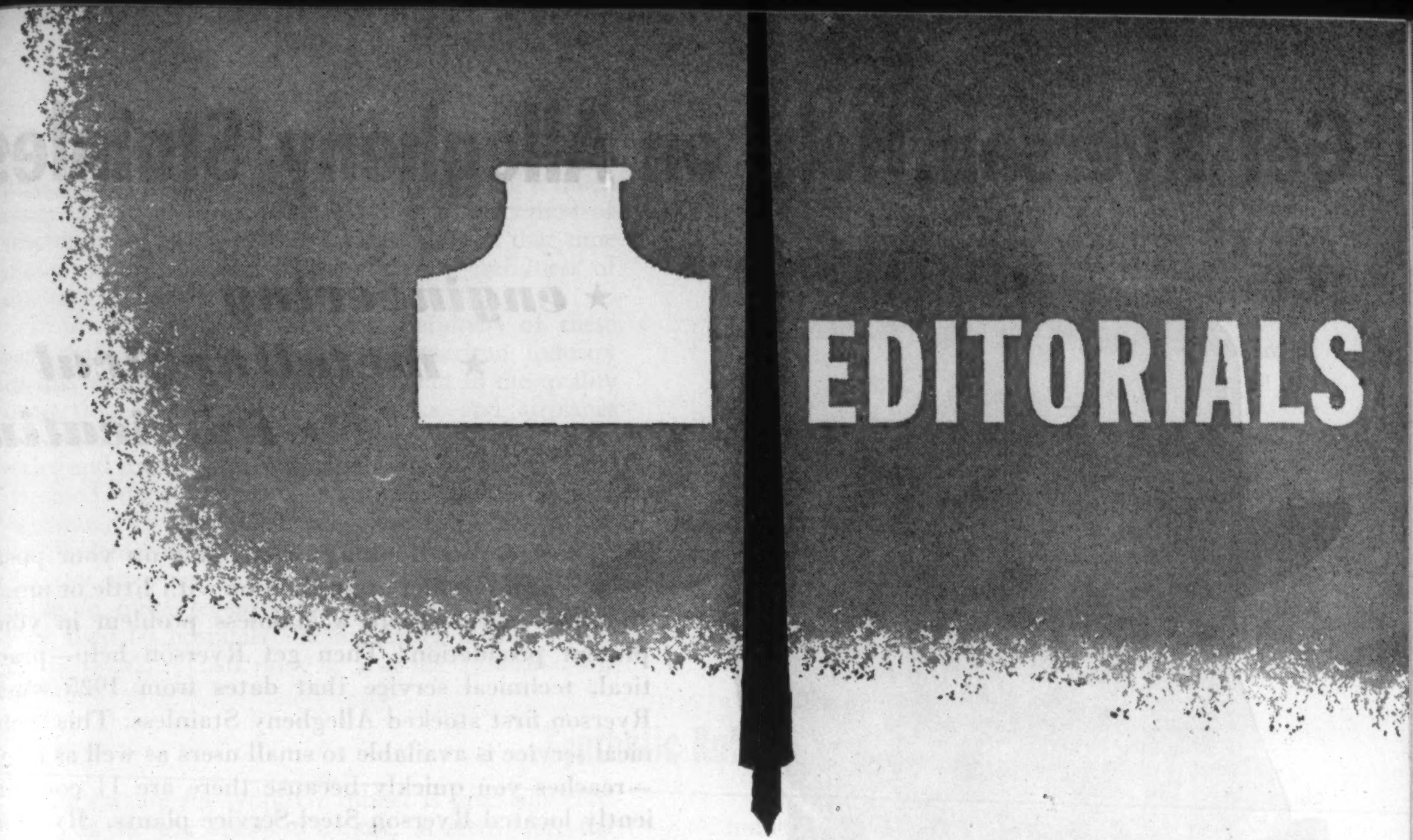
**M & A for June will present this assortment of articles on engineering materials and processing methods: Forming Stainless Steel with Zinc Alloy Dies, Rolled Threads in Various Materials, Engineering Approach to Machine Tool Selection, Metallizing in Production-Design, Magnesium Foundry Practice, Phenolic Fibre Aircraft Parts and Light Strong Iron Castings.**

AN "Open Secret"
OF BEST SUCCESS IN
POWDER METALLURGY
Finer preparation of metal powders..
with
PATTERSON MACHINERY
Satisfactory

**Leading** [illegible] **fabricators of** [illegible] **advantages** [illegible] **by Blenders** [illegible]

President

[illegible] CHINE CO



# EDITORIALS

## The Basic Principles

"Much of the difficulty which is being experienced by many of our college graduates in all departments, including engineering, may be traced to the fact that they do not understand basic principles. Our plans for engineering curricula in the future should lay greater stress on teaching students how to think in terms of principles, rather than to have them devote time to learning applications which change rapidly and which they would have to relearn after they graduate."

So spoke Dr. A. A. Potter, dean of engineering, Purdue University. The great observer and thinker finds out for himself how the same basic principles apply throughout the universe. Thus the law of action and reaction of physics applies to economics and other social sciences. Beautiful tones on a pipe organ, when the vibrations are photographed and reproduced on a film, show graphs of well rounded lines, pleasing to the eye as were the original sounds soothing to the ear. Harsh sounds make harsh graphs. The streamlined automobile or airplane is usually the one most pleasing to the eye.

The great electrical wizard, Michael Pupin, had this power to grasp basic principles. As a herd boy in Serbia he and his companions learned to detect the movements of cattle by holding their ears to the ground and hearing vibrations set in motion by the moving feet of the cattle. They also learned to signal each other by vibrations through the earth, set in motion by vibrating their knives stuck in the ground. This was literally and figuratively the groundwork for his great invention of the application of inductance in telephone circuits involving the Pupin coil.

And so the harmony in and uniformity of, basic principles impressed us the other day when we attended some excellent moving pictures sponsored by Bakelite Corp. on "Bakelite Plastics—Product Design and Molding Technique for Thermosetting Plastics." What little we personally know has been confined largely to metals. We sat down before the screen, expecting to see some strange and new techniques and principles.

Instead, we found the closest similarity to the "dos" and "don'ts" in designing zinc die castings. One must allow for shrinkage in design of the dies; one should avoid undercuts, if possible; put in ribbing for reinforcement; use rounded instead of square corners; do this and that with regard to tapers, fillets, domed surfaces, holes, bosses, metal inserts, styling and surface treatments—all zinc die casting design technique.

Yes, Doctor Potter is right—concentrate on the basic principles, boys!
—H.A.K.

## X-Rays After 50 Years

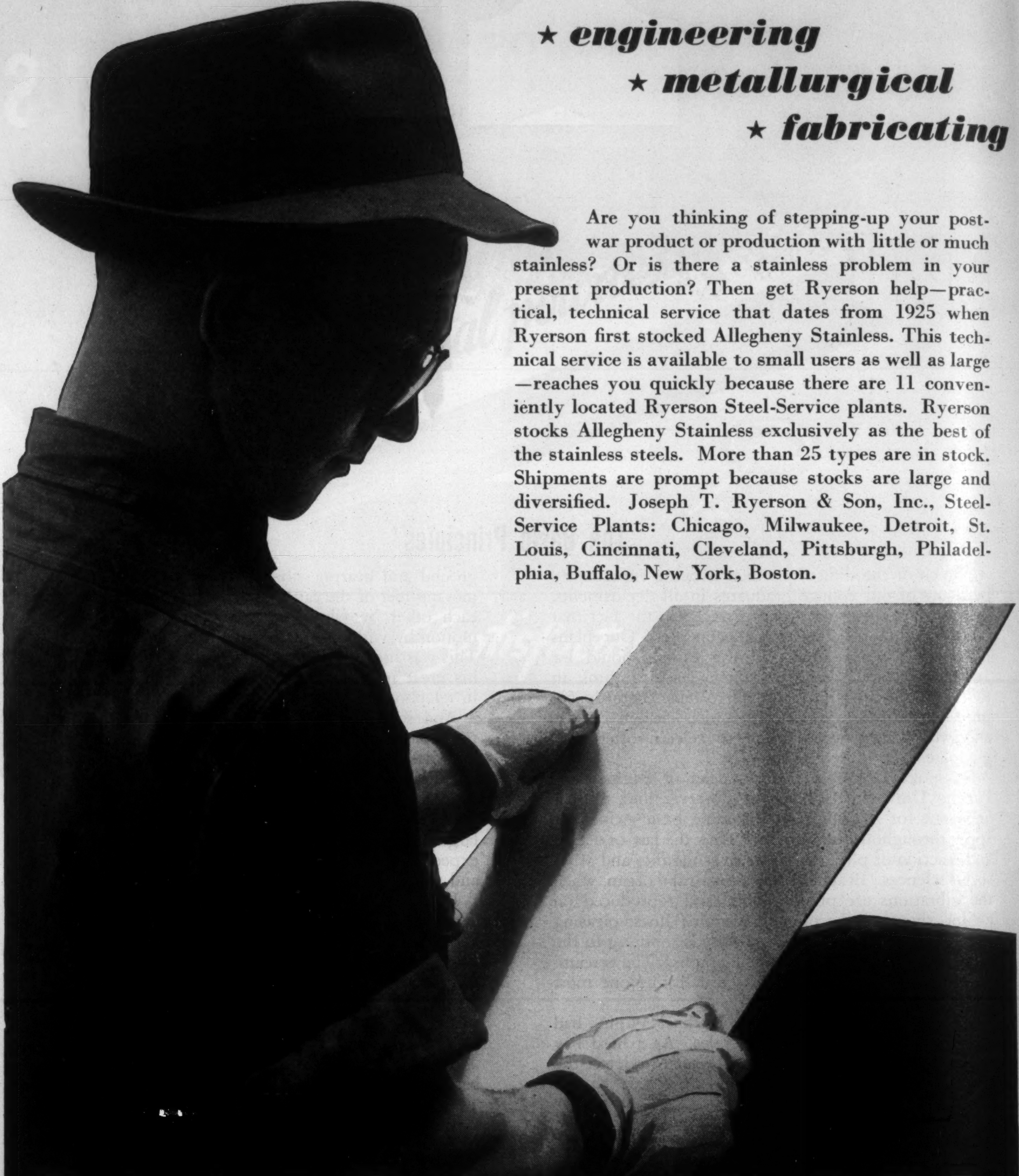
One hundred years ago this spring, March 27 to be exact, Wilhelm Roentgen was born and 50 years ago he discovered the marvelous X-ray. Little did he visualize at the time that his discovery would be the blessing it is today to industry and mankind. Appropriately, he named it the X-ray because he could not define this unknown quantity of great penetrating power.

Many interesting anecdotes are called attention to by the General Electric Co. concerning the early period of this discovery. Newspapers published cartoons, stories and even poems about the "wonderful rays." The idea was broadcast that the new rays might solve such age-old problems as spiritualism and soul photography, and they even reported that

# Get Ryerson Help on Allegheny Stainless

★ *engineering*
★ *metallurgical*
★ *fabricating*

Are you thinking of stepping-up your postwar product or production with little or much stainless? Or is there a stainless problem in your present production? Then get Ryerson help—practical, technical service that dates from 1925 when Ryerson first stocked Allegheny Stainless. This technical service is available to small users as well as large—reaches you quickly because there are 11 conveniently located Ryerson Steel-Service plants. Ryerson stocks Allegheny Stainless exclusively as the best of the stainless steels. More than 25 types are in stock. Shipments are prompt because stocks are large and diversified. Joseph T. Ryerson & Son, Inc., Steel-Service Plants: Chicago, Milwaukee, Detroit, St. Louis, Cincinnati, Cleveland, Pittsburgh, Philadelphia, Buffalo, New York, Boston.



**RYERSON STEEL**

*Do you have a Ryerson Stock List—describes more than 10,000 kinds, shapes and sizes of steel, including the many types of Allegheny Stainless*

the New York College of Physicians and Surgeons used the Roentgen rays to reflect anatomic diagrams directly to the brain of students, thus making a much more enduring impression than the oral method of teaching. On the other hand, there were at that time many strong believers in the ultimate usefulness of the rays, especially in medicine.

In recent years the practical usefulness of these remarkable rays has broadened. American industry in this war has used and is using them in the quality inspection of the ships, guns, tanks, and airplanes which have been devastating German and Japanese cities and munition plants. Certainly Roentgen never dreamed that his city of Munich would be thus devastated by equipment made better by his X-rays which detect flaws in ordnance before it is used.

Great progress in developing equipment has been made in quite recent years. There is the Coolidge tube used by hospitals and industries in many parts of the world. Then there is also the 1,000,000-volt shockproof unit which in 15 minutes can inspect steel plates 8 in. thick. In this connection attention is called to the fact that only a few years ago radium, at $135,000 a gram, was the only source of the same kind of radiation. Now radiation from this 1,000,000-volt machine is equivalent to that produced by 8½ lb. of radium. Only a year ago announcement was made by General Electric of a 2,000,000-volt machine capable of photographing through 8 in. of steel in one minute instead of 15. Even this is not the limit, for there has been perfected a 100,000,000-volt X-ray, details of which are a military secret.

In metallurgical inspection the X-ray has become an essential tool and one of its greatest advantages from an industrial standpoint is speed, which is a factor in increasing output. And its use in medicine is also increasing. With the development of increasingly powerful equipment, the future of the Roentgen rays to mankind and industry are bright with promise of greater benefits. —E.F.C.

## Synthetic Rubber

The picture for synthetic rubber is gradually clarifying as the war draws to a close. It seems sure that much of our present synthetic rubber plant capacity will be devoted to other purposes, or closed down entirely. It is equally sure that a substantial part of it will remain in production, both for those specialties for which some of the synthetics are superior to natural rubber, and as a guarantee against the wild price fluctuations that plagued the rubber industry in predepression days.

Some idea of the extent of our synthetic rubber program is shown by the fact that we have plants capable of producing about twice as much synthetic rubber as our prewar importations of the natural material.

For many purposes the synthetics are distinctly preferable to natural rubber, as, in oil and grease resistance, stability in sunlight, flame- and acid-resistance, etc.

The only rubber items that offer really large-scale tonnage possibilities are tires and tubes. The synthetics, then, must capture or at least seriously invade one of these two fields for big markets. Buna-S seems to be the synthetic at present showing the best possibilities. Advocates of butyl rubber point out that synthetic is the only one now approved by the Government for tubes, and that it is the synthetic that most closely resembles natural rubber in its properties.

For such items as tires and tubes natural rubber is still preferred, although progress in development of the synthetics is cutting into the margin of preference. Natural rubber would probably command a premium price over synthetics on the market today, if it were available. However, there seems to be little likelihood that synthetics, now selling for roughly twice the prewar price of natural rubber, will be able to offer serious competition on price alone to the natural product. —K.R.

## Tin and General Prosperity

We are interested in a statement in the official bulletin of the Tin Producers' Association—"that a sound way to measure the general prosperity of any country is by the amount of tin used per head of population. One reason for this is that those countries using the most tin have the most highly developed agriculture, fisheries and engineering industries."

The bulletin presents a most interesting table showing the consumption of tin per head for some 20 countries during a 10-year period 1929 to 1938 before the war. The data tend to confirm the statements above: The greatest users of tin were the United States and the United Kingdom at 1.1 lb. each per head of population. The smallest user was China at only 0.008 lb. per head—certainly a very wide gap between these, reflecting the relative general prosperity.

In the list of 20 nations, Switzerland stands second at 0.71 lb. per person with Sweden third at 0.59 lb. and France fourth at 0.51 lb. per head. One might expect Germany to stand very high in the list but she is credited with a tie for 7th place with Czechoslovakia at 0.41 lb. per head. Certainly Germany's general prosperity is extensive but no explanation of this lower standing is offered.

But the most interesting example is the U.S.S.R. where the use of tin has lately been rapidly expanding. Before the war only 0.21 lb. was used per head but this represents a remarkable increase of 251% in 10 years. The annual average consumption of tin in the years 1927 to 1929 was 4,462 tons as contrasted with an annual average for 1937 to 1939 of 15,666.

The bulletin points out that there appears to be every reason to think that this Russian expansion will continue and may eventually equal the U.S.A. consumption. This has been achieved by the erection in Russia of large canning plants and the promotion of special agricultural products for canning.

Whether tin is actually an accurate measure of general prosperity it is certain that the world must watch Russia. Here is a nation where industry and agriculture are bound to expand and, whether we like its form of Government or not, Russia must be reckoned with in world competition. The Russian people are living under entirely different conditions than obtained under the monarchy, and their development will bear watching. —E.F.C.

*Skin rolls, shot blasted in 17 grades of roughness, produce Inland Sheets that are easy to draw. The roll shown above has been ground, then shot blasted on one end to show contrast between ground and shot blasted surfaces.*

# AN INLAND ACHIEVEMENT

## that revolutionized deep drawing

Several years before the start of World War II Inland engineers and metallurgists developed a new type of cold rolled sheet that solved a baffling deep drawing problem. The part was a deep drawn front fender on which breakage had been running from 30 to 50%. The special sheet produced by Inland resulted in thousands of these difficult fenders formed with only 3% average breakage.

This Inland development was a special method of preparing rolls for the temper mills. Instead of the usual smooth and bright surface, the Inland sheets were given a new type of surface that permitted radical improvements in steel processing. It also enabled fabricators to improve die performance. This "new surface for severe draw jobs" held the die compound, permitted better control of slippage, required less hold-down pressure, and provided freedom from scoring, resulting in more uniform draw distribution so necessary and desirable in meeting the intricate drawing requirements of modern designers and fabricators.

This is only one of the many product improvements pioneered by Inland—improvements that are making better equipment for war and that will help produce finer peacetime products.

An Inland specialist awaits your call to tell you about these developments and their many applications.

**Bars • Floor Plate • Piling • Plates • Rails • Reinforcing Bars • Sheets • Strip • Structurals • Tin Plate • Track Accessories**

# INLAND STEEL COMPANY

**38 South Dearborn Street, Chicago 3, Illinois**

***Sales Offices:* Cincinnati • Detroit • Indianapolis • Kansas City • Milwaukee • New York • St. Louis • St. Paul**

# And Now...Japan!

## an Editorial

The complete defeat of the German army is at last a fact and the war in Europe is officially over. Long expected and awaited, the V-E day announcement is still the happiest news of these times, marking a glorious triumph over the most formidable military machine and general menace in all history and bringing tremendous release of personal tension to millions of Americans directly or indirectly involved.

The happiness of Victory is greater because it has been such a bitter, heartbreaking and discouraging campaign—always bitter for our fighting men, often heartbreaking for their families and friends, sometimes discouraging for those entrusted with the task of producing the materials and machines of war. But it was also a successful campaign and though that fact cannot heal the wounds and banish the sorrow it brought, it is sufficient justification for the heavy cost and a more-than-adequate answer to the criticisms we have all made of certain phases, aspects or details of the job.

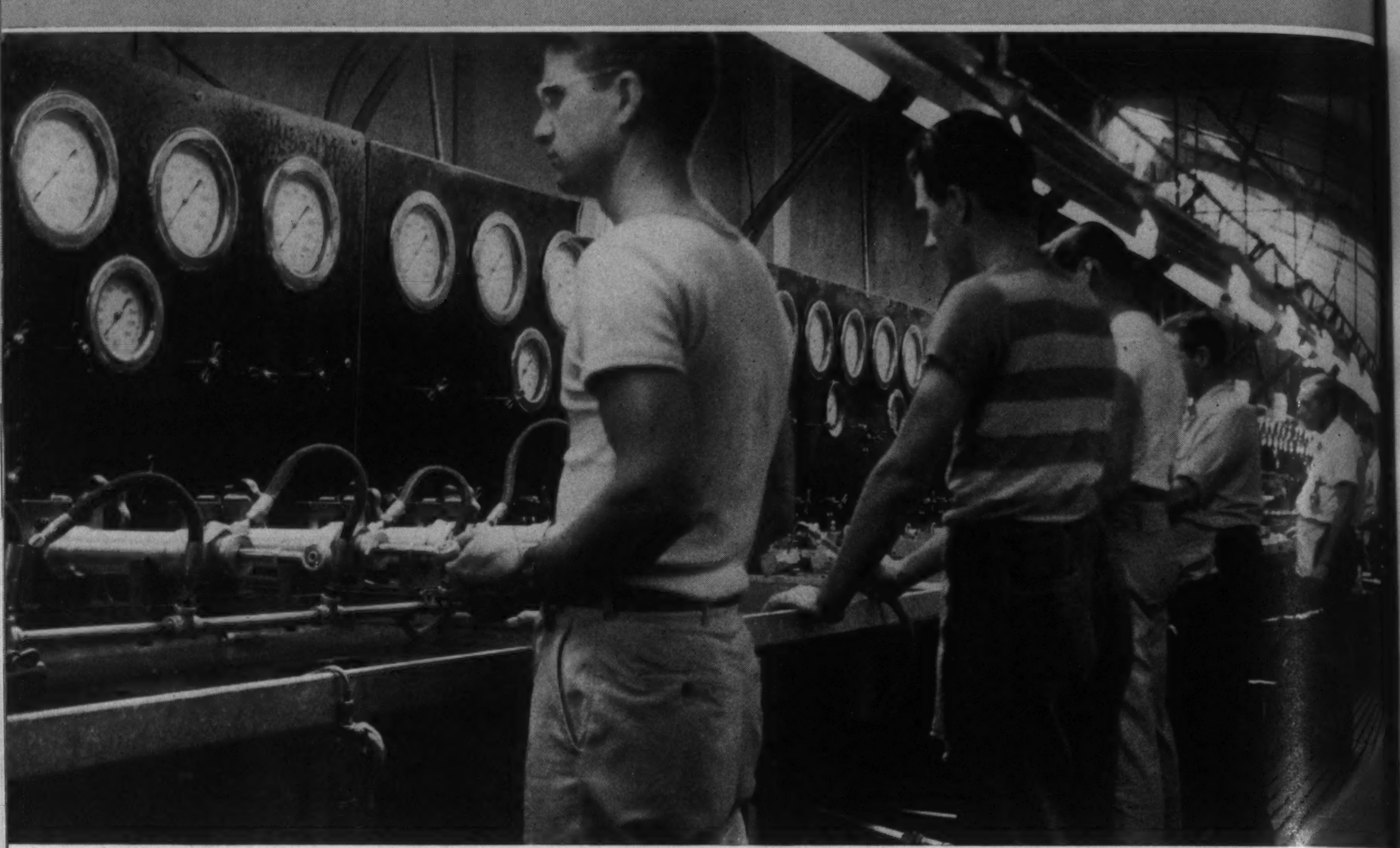
But in our joy over Victory in Europe, we must not forget that it is *only* that—Victory in *Europe!* We still have an even more fanatical enemy to destroy on the other side of the world. We still must produce additional millions of projectiles, thousands of planes, tanks and guns, and an unbroken stream of raw materials for that purpose. We still must ship these weapons over thousands of miles of land and sea and, what is most important, we must still face heavy losses of men in the actual fighting.

Cutbacks of considerable dimension are coming (have, indeed, already started) and will introduce new problems of reconversion, re-tooling and temporary unemployment. While these will demand our attention to an increasing extent they must not be permitted to blind us to what is still the No. 1 job for all of us, engineers, industry in general, America as a whole — the speediest possible total defeat of our last remaining Axis foe.

Engineers in the metal-working industries have two formidable war-born tasks still ahead of them—(1) the defeat of Japan and (2) the reconversion of our plants, products and professional activities to a peace time basis. From now on the second should receive a large share of our attention and may well turn out to be a bigger job than the first, but the first must still have the top priority everywhere!

FRED P. PETERS

**A Materials-and-Methods Article** Smart engineering in a metal-working plant inevitably involves a close tie-in between the selection of materials and the processing methods used for its products. The Adel Precision Products Company's system for controlling and coordinating its materials and methods, described in this article, is responsible for the quality and efficiency of its output and is a worthy model for other metal-working plants to follow.



*Battery of test boards for final hydraulic tests.*

# Integrated Materials and Methods Control

**by THE ENGINEERING STAFF** *Adel Precision Products Corp., Burbank, Cal.*

as told to

**GERALD E. STEDMAN**

THE WEST COAST is a part of the industrial United States. Too few have ever recognized this until this war. Politics, translated into economics (penalty freight rates and breaking points) have made it difficult for the West Coast metal working industries.

Due to distance factors between the West Coast and the Central East, with its long established national supply centers located in areas of concentrated and comprehensive production plants, general warehouse stocks in Los Angeles area are held to a minimum of diversification as to analysis, range of shapes and sizes in standard mill products available for quick delivery. While the national emergency developed new source supply centers together with marked increase in rolling, extruding, casting and forging plants in the West with attendant relief for

Western manufacturers, parallel industrial expansion in aircraft, shipbuilding and ordnance, demanded further dependence on Eastern sources of supply.

This condition, resulting in quantity warehouse or mill shipments on the order of two to nine months' delivery, coupled with general war emergency restrictions on diversified tonnage orders, and 60-day plant stock limitations, have further increased the difficulty of obtaining suitable materials in the Pacific Coast area on a minimum "type-size-condition" basis for precision production in a short flow time. Therefore, substitutions, variance in stock heat-treated condition, entailing numerous specification deviations and use of acceptable alternates to meet usage requirements have been constantly present problems with Adel Precision Products Corp. in its coordination among engineering, purchasing, shop production, vendors, and Army-Navy inspection.

Keeping in mind machining requirements of hydraulic equipment and Adel standards of "quality control" related to the West Coast background in which specified metals are difficult to obtain within proper time tables, there has been occasioned the Adel need for technical control of: (1) Materials and stock, (2) processes, (3) surplus requirements.

Few manufacturers have had to work more precisely in metal than Adel—its production being completely in aircraft hydraulics. All Adel products require unusual precision (even to limits under 0.00001 in.).

Hydraulics require practical balances of strength and elasticity to withstand as high as 10,000 p.s.i. hydraulic pressure. Adel materials must function satisfactorily in temperature ranges from minus 65 F. to plus 160 F., with average assurances conforming to A-N requirements, and in accord with A.S.T.M.—A.S.M. procedures. Internal structure considerations of its varied metals, relative to tough-hard surface finishes and internal resiliency factors necessary to take wear and shock of instantaneous pressure applications common to 1500/3000 p.s.i. hydraulic combat aircraft range, has demanded metallurgical finesse.

To meet these severe performance requirements successfully, H. Ray Ellinwood, Adel president, recognized that a well-rounded, coordinated engineering *and* metallurgical staff was essential. Typical of the steps that have resulted from this approach have been inspection standards for microscopic gaging and established regulations for correct selection and processing of basic materials available on the Pacific Coast.

Among the engineers, production executives and metallurgists who coordinate Adel's materials and methods problems as outlined in this article are J. W. Kelley, chief engineer; Otmar Kehle, chief design engineer; J. Lynn Reynolds, chief metallurgist; Edward Wildes, raw materials engineer (including outside forgings, castings and other fabricated forms); Wm. Bristow, production processing engineer; Harry Miller, in charge of induction processing; H. Prelinger, chief chemist; J. B. Van der Werff, administrative engineer; Lee Baldwin, chief liaison engineer; R. J. Baller and A. E. Morgan, supervisors; George Plumb, physical research engineer; H. F. Patterson, inspection quality control manager; and J. W. McDonald, chief inspector.

## Materials Stock Control

The staff has created a color-key system designating chemical analyses, physical properties, pertinent conditions (footage, size, shape, vendor and magnetic inspection), laboratory acid identifications for stainless—all tied into the company's purchase order coding with integrating dates.

This system is made out for each order. These records are distributed to raw material acceptance stores, heat-treating and metallurgical control files. All releases to production are signaled. They are tied in with shop order part numbers, providing space for fabrication warning situations. A sample of this control appears herein. The basic Adel materials list is:

1. *Corrosion resistant steels:*
    A. Bars and shapes. .302, 416, 440
    B. Sheets . . . . . . . . .302, 410, 414
    C. Tubing . . . . . . . .302, 410, 406 (4% Al)
2. *Carbon and low alloy steels:* (Alternate N.E. steels regularly substituted in lieu of S.A.E.)
    A. Bars and shapes. .C1019-22, 1090, 4615, 4130, 6150, N135
    B. Sheets . . . . . .1010-15-20, 1025-30, 4130, 1090, 6150
    C. Tubing . . . . .1010-15-20, 1025-30, 4130
3. *Aluminum:*
    A. Bars and shapes. . . . . . .24ST, 17ST, 14ST
    B. Sheets . . . . . .24ST, 25 ("0" and ¼ hard)
    C. Castings . . . . . . . . . . . . . . . . .356T6, 13X
4. *Brasses and bronzes:*
    A. Bars and shapes. . Electrolytic copper, S.A.E. 72, Naval, aluminum bronze, phosphor bronze
    B. Sheets . . . . .Electrolytic copper, S.A.E. 72, phosphor bronze
    C. Tubing . . . . .Electrolytic copper, phosphor and aluminum-bronze, beryllium-copper
    D. Castings. . . . . .Naval brass, phosphor and manganese bronze, beryllium-copper
5. *Irons:*
    Ni-Resist,
    #30—#35 Gray
    #40—#50 Alloy as cast and heat-treated
6. *Specials:*
    Inconel, Alnico, manganin, nickel-chromium, beryllium-copper, Monel.

These materials are held in open stores until Adel quality control and the metallurgical staff has cleared them for production inventory. Receiving inspection involves such considerations as dimension, surface condition, general structure by conventional step down micro-inclusion pattern, and hardness checks with uniformity quench surveys.

Steel, brass and bronze have an Adel coding by number and letter coordinating with A.I.S.I., S.A.E., and N.E. requirements. Each received shape has an Adel code number stamped on one end, applicable to that particular shipment. The P.O.N. (purchase order number) is also identified as "tie-in." Adel realizes that customary color markings are hard to differentiate (for example, color blindness of employees); they may be obliterated in travel, and could cause a number of shop difficulties.

The Adel material handling system uses color markings only to differentiate stainless from carbon and low alloy steel. For example, its color code is:

1. No. 440C: 58 Rc. type is yellow intermittently striped.
2. No. 416: 38 Rc. type in 25 to 32 Rc. range is butt end red painted.
3. No. 416: 28 Rc. type in 25 to 32 Rc. range is painted blue on ends.

## Production Control

The P.O.N. is carried on all production. Therefore, in any material fabrication difficulty arising on any production work and involving heat-treating identification, shop orders can be quickly clarified. This is one of the unique features of Adel *quality control*. The method simplifies metallurgical control, supervisional coordination, inspection and fundamental reports.

As Edward Wildes, raw materials engineer reports (it is his responsibility to coordinate with engineering, production control, outside vendors, Army-Navy inspection, and his group has maintained unusually precise supervision of raw material, ordering, receiving, storing and issuing):

"Aluminum stock carries this key-purchase order marking with the aluminum manufacturer's standard designation as to the particular alloy. Castings bear the part number. The foundry casting date and heat designation is evidenced. At Adel, the U. S. Navy handles general raw material inspection. All accepted stock carries the 'anchor' approval stamp. A complete file of certified chemical and physical reports (or U.S.N. anchor approved billings) is maintained, keyed to the P.O.N. tool steels which have their own combination color-number codes since they are used for processing, and not for the end usage of production."

In the production processes, technical supervision has originated a series of close procedures-controls. These are concerned with furnace atmospheres, bath media, cyclic "heat-quench-temper," specific time-temperature controls with interval synchronization to achieve the desired balanced structure. This series of procedures also has established exacting engineering requirements for the family of Adel products, and in particular relation to the West Coast material-procurement situation.

Heavy concentration of aircraft production in Southern California and its attendant crescendo of industrialization has added to the problem. As the largest producer of hydraulic systems, with electrical and related actuating accessories allocated under A.S.U., the contentions under which this engineering and metallurgical staff have ably performed in relation to fluctuation of delivery schedules, revisions by joint committees, and the requirements of the national emergency aircraft combat—all have made the Adel engineering and metallurgical achievement the more interesting.

This commendation is the more important in consideration of deviations from standard processes caused by absence from specified material sources. The conditions demand fluidity in revision of technique in heat-treating and shop procedure to maintain *quality control* of production in rapid flow on scheduled bases. Adel's metallurgical system has assured complete compliance with these requirements, even to service durability of its units.

## Materials Engineering

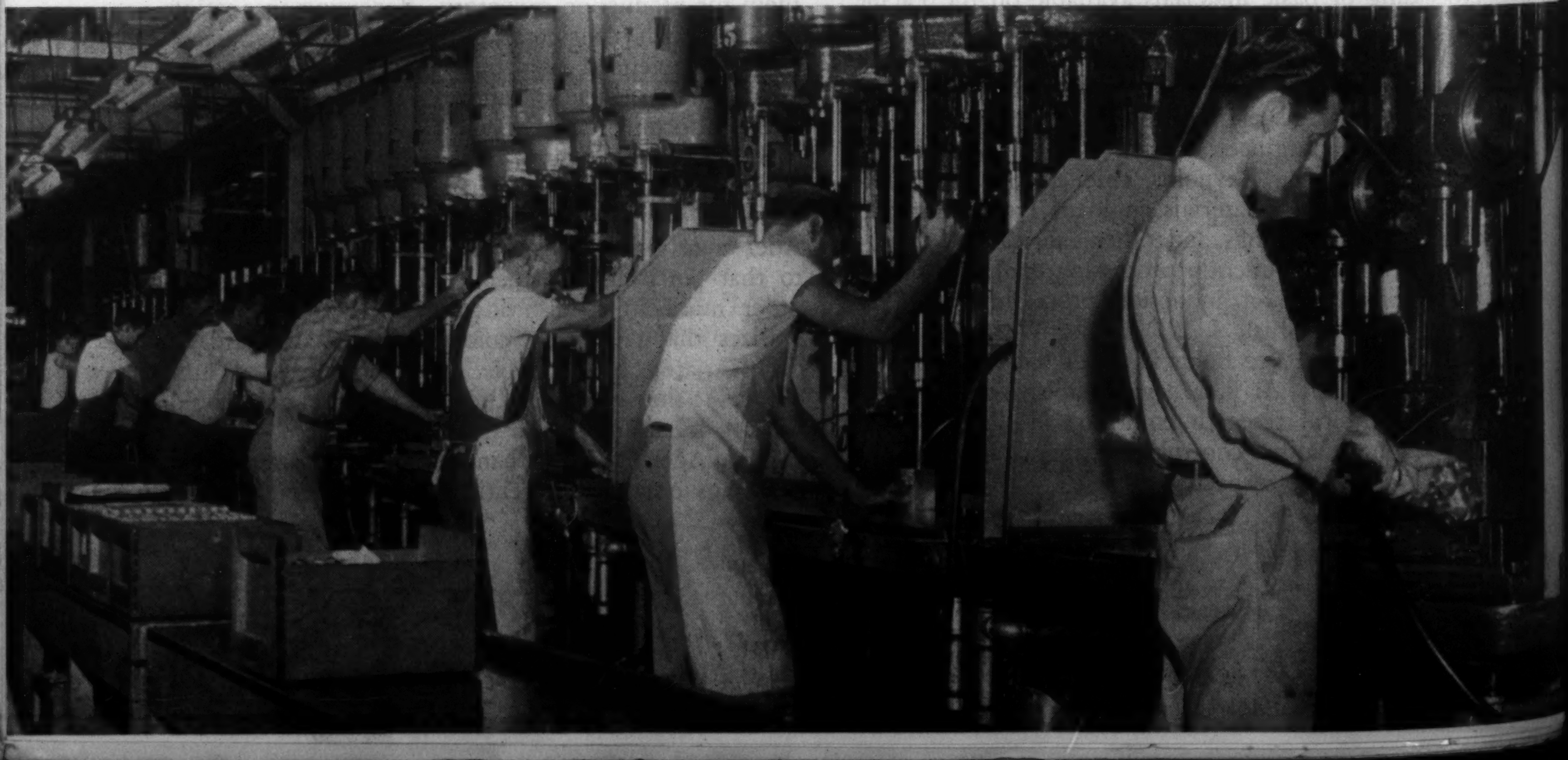
Stemmed from its comprehensive research to meet severe service demands, the Adel engineering and metallurgical staffs in liaison have been governed in their discriminating selection of materials by these principles:

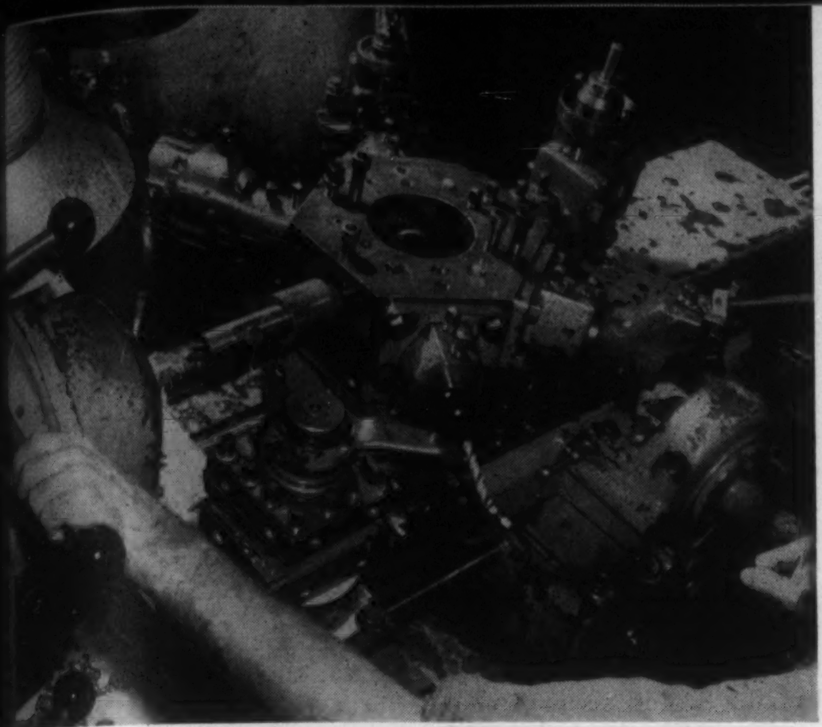
1. Economic production.
2. Facility of fine finish.
3. Response to proper heat treat.
4. Balanced physical factors (such as strength and resiliency).
5. Resistence to corrosion.
6. Machinability index rating.

In this technique, Adel has followed the concept of "realizing that a higher first cost of raw material is relatively of less significance than an allegiance to the basic factor of complete assurance in dependability of service." Light weight with adequate strength is one of the Adel engineering principles in line with design simplicity.

Some concise discussion of the materials used seems in order here, with particular reference to aluminum, stainless steel, carbon steels, low alloy steels, brasses and bronzes.

*A part of the machine shop. A progressive machinery drill bank.*





*A turret lathe machining cartridges for valve assembly.*

**Aluminum Alloys**

Adel has made considerable use of high strength heat-treated aluminum bar (24ST, 17ST, 14ST) for highly stressed units. Alternatively, seeking to eliminate extensive machining and to win special surface configuration where unit envelope plane installations permit, service usage that allows cross section changes commensurate with reduced tensile and enduring properties, have caused Adel to resort to permanent mold castings of 356T6.

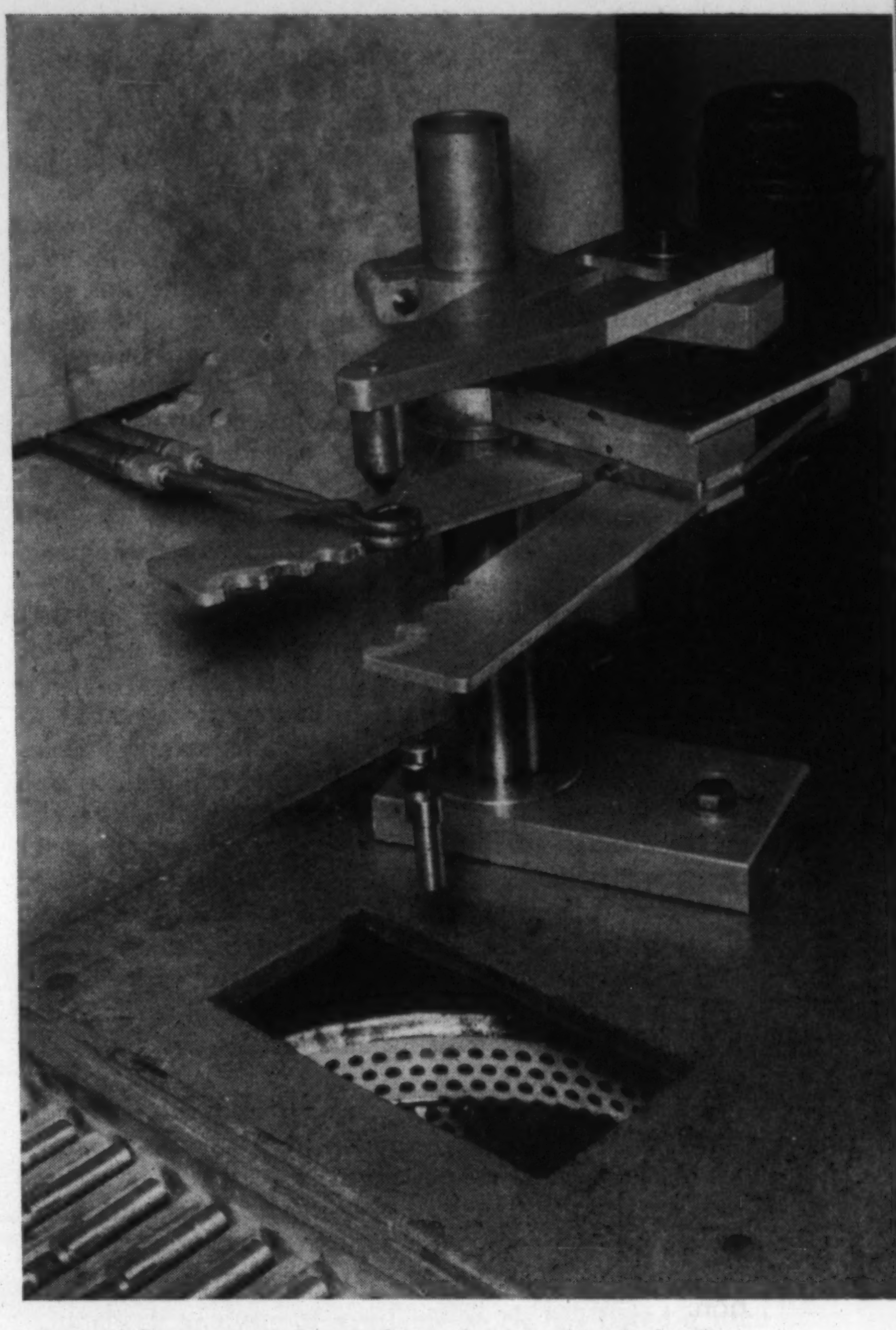
In this regard, advantageous use of metal for precise finish has tended to make Adel favor the die casting alloy 13X. Hydraulic hand pump cylinders of 356T6 alloy and barrel finishes, machined and anodized to assure a high resistant surface, were first developed by Adel.

This technique eliminated the pressed steel wear sleeve from conventional hydraulic setups: (1) Reducing production costs, (2) expediting quicker fabrication, (3) increasing service durability. All 24ST, 17ST, 14ST, 363T6, and 13X parts are anodized—the chromic acid process being used.

**Stainless Steels**

Adel makes extensive use of the hardenable chromium stainless steel series; particularly using the medium hardenability and free machining type 416, as well as the high hardness type 440. These steels are unusually advantageous for hydraulic system fabrication. Non-corrosive, inherently possessing unusual facility for instantaneous forming of protective film microscopic surface, these steels prevent possibilities of leakage, the constant enemy of proper hydraulic function.

As explained by Reynolds: "This stabilized and minute non-tarnishing film on rotating, sliding, and sealing parts naturally provides surface cleanliness and facility of disassembly, eliminating plating erosion possibilities. The loosening of microscopic oxidation which could become embedded or mar the passage seal, with consequent hazard of leakage, is reduced by use of these types of stainless. They can be processed to secure balanced hardness. They function to provide resiliency with low coefficient of distortion. They provide high uniformity of section-depth hardness with freedom from scale, particularly by neutral salt heat treatment."



*A special automatic quenching fixture. An induction heated cam released for oil quenching.*

All Adel parts in these stainless types are fully passivated prior to production release. Of the 93 finish parts in stores, 71% of the internal pieces for hydraulic selector valve and control are of these steels. They afford minimum plating requirements. They assure absence of crippling leakage under high service pressures.

While some Adel parts are made of type 416 annealed, most pieces are in the 25 to 32 Rc. range (250 to 300 Brinell). A small percentage falls in the 35 to 42 Rc. classification (325 to 400 Brinell). This steel is generally purchased in the 25 to 32 Rc. condition, because it has a better machining rate and its parts can be directly processed without further heat treatment. Only a simple final passivation is necessary to produce superior micro finish, as compared with the use of commercial anneal stock. Since the 25 to 32 Rc. range involves the 125,000 to 150,000 p.s.i. spread, this specification covers Army-Navy requirements for important hydraulic fittings above 90,000 p.s.i. with adequate wear resistance requirements.

The 440 type stainless, purchased in the annealed state (25 Rc.-225 Brinell max.), is generally heat treated to 55 to 60 Rc. Such Adel products as poppets, ball or piston checks and other hydraulic parts where high wear-resistance functional characteristics are primary, are fabricated from this stainless. Other components, such as certain hollow cylindrical spacers, are more economically produced from type 406 (4% Al). These are made from tubing, water quenched at 1750 F, tempered at 550 F. to 35 to 40 Rc., to agree with engineering service requirements of resistance and rigidity.

Adel makes some use of 18 and 8 (302 and 303 types) annealed stainless, and one-fourth hard for small washers and spacers. These metals are specified where extra corrosion protection is essential to meet an 80,000 to 125,000 p.s.i. This stainless series is likewise employed on Adel non-magnetic parts. Also, there are certain spring applications which involve special corrosion problems in which Inconel wire is specified.

In the Adel setup, the general metallurgical classifications and applications for the stainless steels are:

*Type 416:* Annealed, 25 to 32 Rc. or 35 to 42 Rc. range; the higher hardness range being used where high surface stress loading and increased rigidity are paramount factors.

Needle stems, poppets, seats, piston valves, cages, spacers, caps, cartridges, push rods, actuators, spring-piston stops, fittings, bushings, sleeves, rotors, adjusting screws, nipples, heads, adaptors, bolts and nuts, lock nuts and pins, guides, inserts, washers, spacers, rings, shafts and hubs are involved in this classification.

*Type 440 C:* 1.00 to 1.15% C, heat treated 55 to 60 Rc. Poppets, actuating poppet rods, rotors, sleeves, shafts, stems, plungers, pistons and actuating shuttles are herein concerned—parts of high surface hardness and rigidity with good corrosion resistant qualities.

## Engineering Alloy and Carbon Steels

In its 4-way coaxial hydraulic valve, Adel engineering design employs a cam shaft which requires unusually fine micro-structure in the 0.15 to 0.20% C range. This material demands a high surface stressed steel requiring peculiar core physicals. Adel fabricates such cam shafts from S.A.E. 4615 (N.E. 8617) carburizing at 1650 F (liquid or gas) for 0.030 to 0.040 in. case depth, direct quench in oil at 1475 to 1500 F to obtain maximum case quality. The work is then tempered at 400 F, for 1 hr. to 58 to 63 Rc.

Less important shafts are produced by Adel from N.E. 8617, 9415, C1019, C1022, carburized at 1650 F (liquid or gas bath) with case depth varying from 0.030 to 0.040 in., direct quench from 1650 to 400 F for an hour soaking interval to achieve 55 to 60 Rc. on wear surfaces. Core hardness for Adel shafts having unit bearing load on hardened cam surface of the order 125,160 p.s.i., take the 25 to 35 Rc. range. Lower order, stress lift shafts vary 22 to 30 Rc.

Because of the small diameter of Adel hydraulic handle ends (sometimes threaded), it is usually essential that these be drawn in a lead or neutral salt bath to achieve 25 to 30 Rc. Adel takes advantage of atomic welding and hydrogen brazing, to gain all economies possible in certain low-surface stress lift cams and levers. These are of pre-fabricated dual steels; such as 0.10 to 0.20% C sheet, C1022, 1025, or 4130 (N.E. 8630 alternate) bar or plate with 0.010 to 0.020 in. case depth with 50 Rc. as hardness lift surface minimum requirement.

An 0.004 to 0.005 in. electrolytic copper plating is used to coat areas where decarburization in hydrogen brazing would show adverse effects. This protective coating also precludes carburization other than on wear surfaces. It economically secures proper strength-finish characteristics. This Adel technique of protective plating on non-carburized surfaces is also used on singularly formed shafts, fabricated from bar stock or upon forgings previously mentioned.

Certain of Adel hydraulic precision parts, such as actuating cylinder barrels, internal sleeves, rounds for pistons and rods are purchased heat treated in tubings, S.A.E. 4130 (N.E. 8630 alternate); their wear surfaces being chrominum plated 0.001 in. finished depth minimum. Hexagon stock is also used for certain external plugs or fittings where high tensile is required, such parts being externally cadmium plated.

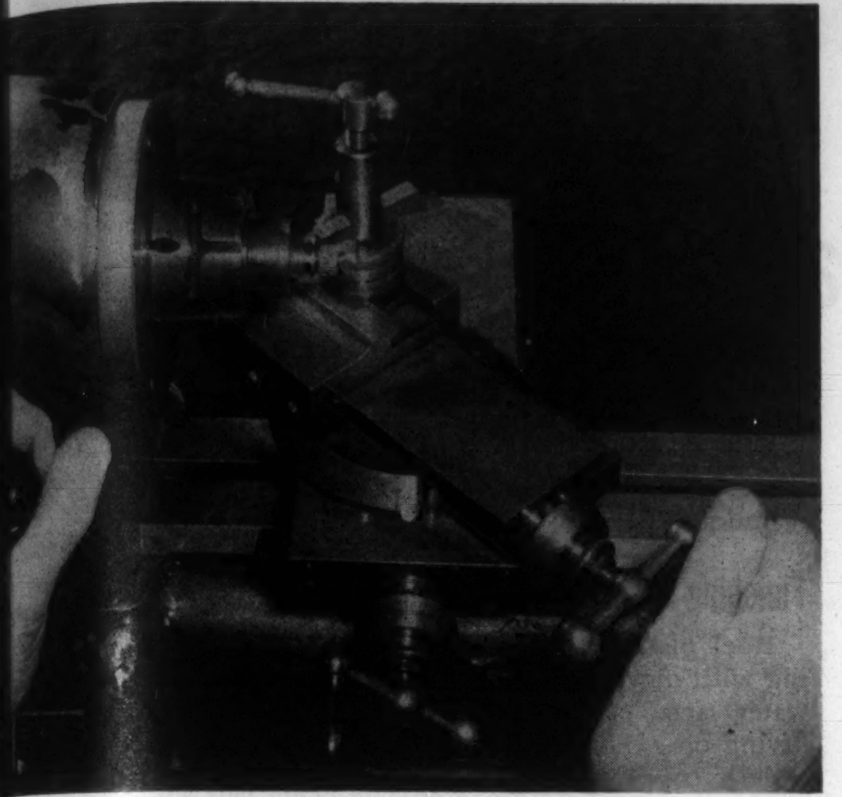
Coiled and flat springs are procured as stock, fabricated from 0.85 to 0.95% C steel, processed to Army-Navy requirements, but not plated. In certain instances, S.A.E. 6150 or 9260 is specific where tough resiliency properties are essential. For maximum corrosion resistance, Inconel is used. Adel processes some special spring from 1090 stock (41 to 45 Rc.), stress and embrittlement relieved after the Bullard-Dunn cleaning process.

For special wear-resistant surfaces, NI35 modified is purchased in condition responding to nitriding with a 0.010 in. case depth. S.A.E. 1020 normalized bar stock (or 0.05 to 0.25% C sheet stock to A.S.T.M. 109 specified finish and temper) are used for miscellaneous Adel parts. These meet comparatively low stress requirements.

As a general rule, Adel resorts to chromium or cadmium plating of carbon and low alloy steel pieces. These are such parts as plugs and fittings which screw into bodies having external surfaces cadmium plated. Parts for internal usage have chromium plate protection when service specifications demand. Where it is necessary to heat treat such parts, procedure is in line with AN-QQ-H201 requirements.

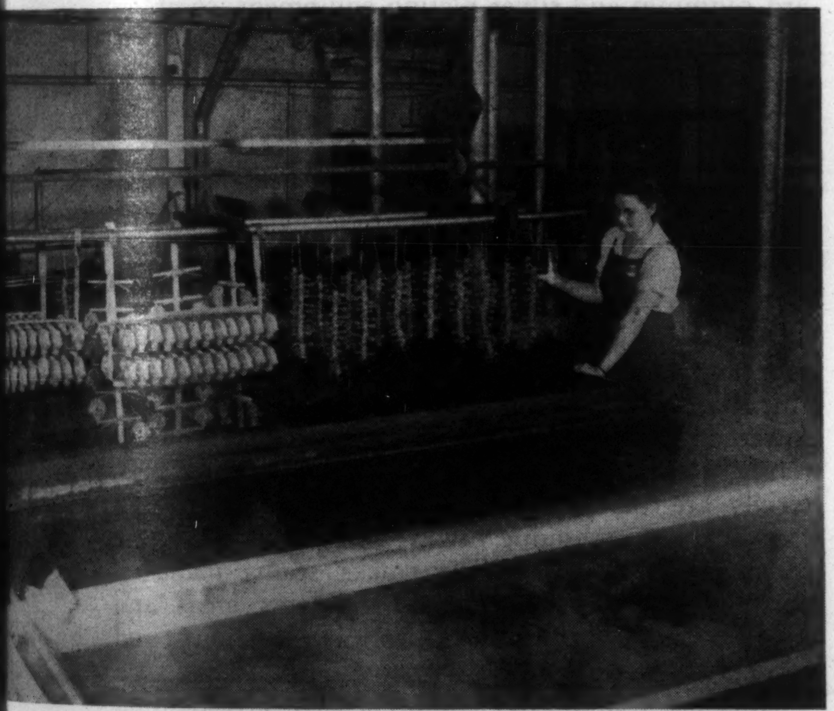
## Brasses and Bronzes

Adel's metallurgical technique with brasses and bronzes is likewise precise. Certain parts, such as electrical connection posts, shims, plug caps, filter bowls, special bolts, retainer plates and metering orifices are of one-half hard commercial brass. Certain applications of higher strength requirements (such as nuts, lock and wiping rings, threaded inserts in aluminum, bushings and glands) are pro-



*Precision machining of a valve gage.*

*The anodizing installation with loaded racks above the tank.*



cessed of one-half hard naval bronze. Large filter bowls are fabricated of pressure molded manganese bronze. Certain high production naval bronze machinings are from centrifugal castings.

In the Adel hydraulic metering fluid pumps, parts are machined from 91 Cu, 7 Al, 2% Si round bronze stock to meet special wear and corrosion operating conditions. For specific electrical parts, such as brass sleeves, S.A.E. No. 72 metal is brazed, using a low melting silver solder at 1400 F to soft iron core part for low stress application. Where higher strength properties are required, a phosphorus, manganese or aluminum bronze or beryllium-copper sleeve is brazed to soft iron core, annealed and fused at 1400 F with subsequent heat treatment to meet a 50,000 min. to 175,000 p.s.i. max. tensile requirement. In some electrical units, springs are made from phosphor bronze tempered strip.

## Status of the NE Steels

Increasing use of induction hardening has enlarged the scope of Adel investigation, both as to materials and processing. For example, wear surfaces, requiring 50 to 60 Rc. hardness and working in the "skin" to 0.050 in. case depth in the carbon steel ranges 0.32 to 0.40% are water quenched. Adel's quality control, backed against economically priced metals of fine grain and high cleanliness, particularly in cold work requirements, processed under West Coast limitations and need for quick deliveries—all have led to wide use of readily obtainable N.E. 8630 aircraft steels in sizes under 1½ in. shapes.

Quoting William Bristow: "Since the rapid and continued availability of the 1040 to 1050 series carbon steels has been problematical due to ordnance requirements, plus the fact that the higher manganese series, straight or low alloy, have been readily procurable, only in the 0.45% C range, these grades are not being used in production parts."

The Adel use of N.E. steels has followed advanced research practice in relation to:

(1) Basic heat treat principles.
(2) Experienced familiarity.
(3) Close attention to details.
(4) Thoroughness of metallurgical findings.

For example, N.E. 8617-15 in the carbon range 0.15 to 0.20% is a general alternate for S.A.E. 4615. Though Adel of controlled necessity employs 8620, its check analysis of available stock has noted a high of 0.24% C. This, with a top manganese percentage of 0.90% results in carburized core hardness as high as 45 to 50 Rc. in small diameters and thin cross section work. These are in excess of Adel limitations for balanced physical properties.

Chief metallurgist-chemist H. Prelinger, is quoted: "Some use is made of the 9400 series, though we have not found it as reliable a general purpose steel as the 86-8700 series; 86-8730 is a regularly used alternate for 4130 series for parts requiring 125,000 to 150,000 p.s.i. ultimate tensile, as well as for wear surface hardened by the high frequency induction heating process to the 53 to 58 Rc. range. Research work was done in late 1942 on the 8620 series in the 0.19 to 0.24 C, 0.75 to 0.90 Mn, 0.20 to 0.30 Mo, 0.45 to 0.55 Cr, 0.50 to 0.60% Ni range for ⅝, ⅞ and 1½-in. rounds. Center or one half radius positioned tensiles were rough machined and heat treated for ⅝-in. rd. as ⅝-in. diam., ¾-in. rd. and 1½ in. rd. as ¾ in. diam.; finished machined to 0.440 in. and 0.503 in. throat diameters respectively, and tested. It was determined that this steel has possible utility in bolts, rods, plugs and fittings in the 100,000 to 125,000 and 125,000 to 150,000 p.s.i.

ultimate tensile class, as an alternate to 4130 or 8630."

This is in line with previous work done in 1933 to 1935 on 0.23 C, 1.30 Mn, 0.25% Mo electric furnace steel for a medium speed Diesel engine connecting rod bolt application, which gave satisfactory service usage.

## Process Engineering: Heat Treating

The Adel heat-treating department is equipped with complete facilities, both gas-fired and electrical, balanced by emergency restrictions applying to West Coast areas; particularly in relation to alternating standby. Adel carburizing can be accomplished in gas-fired liquid baths, electric, L & N vapo-carb, and Homo-carb furnaces.

In this processing setup, the Adel metallurgical staff has developed a method of grounding the high nickel alloy spiders submerged in the liquid baths, eliminating all electrolytic tendency on suspended parts which have particular non-carburizing areas protectively copper plated. This technique precludes transfer to or deposition on surfaces to be carburized of a thin copper film. Without such grounding, the parts might be found non-passable in inspection because of secondary electrolytic action aroused, causing a faulty or sub-normal hardened carburized cam surface.

Atmospherically controlled 8 x 10 Hayes electrical and gas-fired 18 x 24 Knapp furnaces cover heating temperatures from 1400 to 2400 F. This tandem bank is supplemented by 16 by 20-in. Knapp gas-fired furnaces of the 1200 to 1900 F range.

The group of L & N Homo-draw furnaces have a 1250 F max., while Blakeslee degreasers are available for use in tempering operations of the 175 to 225 F range. A multiple, gas-fired furnace setup with carbon steel, high nickel alloy and special material pots, covers lead bath requirements and permits neutral salt application in the 350 to 1850 F temperature range. These permit the advantage of quench to timed cycle bath tempering techniques.

All furnaces have L & N micromax automatic recording. Adequate quenching baths, water, oil, and brine are advantageously positioned adjacent to the furnace banks. Such quench facilities have large capacities and were installed for high production flow. The main oil quench system is serviced by an unusually large re-circulation setup.

Recent installation of a 5-kw. thermonic induction heating unit has increased Adel hardening and brazing diversification possibilities. Most parts are relatively small. The addition of an electronic timer for release of such heat-treated parts from the holding mechanism is of Adel origination. This timer is synchronized with the heating circuit. Its operation has materially increased efficiency and range of operation. Adel has found it feasible and economical to accomplish certain fusion brazing operations in the L & N hump furnace unit.

The company's use of high frequency induction hardening is expanding. This treatment is applicable to localized hardening in the 25 to 6 Rc. range. Adel finds the method of heat treatment particularly advantageous in salvaging finished parts where processing operations after standard heat treatment have reduced hardness below acceptable limits. The technique is also particularly valuable where engineering change requirements necessitate marked increase in hardness of parts already finished or in process.

Stainless steels have been processed rapidly, economically, and satisfactorily by Adel with high surface cleanliness and correct structural relation to meet engineering requirements, oil quenched 1700 to 1900 F carbon and carbon alloy steel depth hardening as a substitute for carburizing is a working procedure. Tool carbide tips as well as low temperature eutectic and silver solder brazing on parts involving individual pre-fabrication, either of the same or dissimilar metals, are processed by this induction hardening technique.

## Finishing and Machining

Adel plating facilities cover chromic acid anodizing with individual batteries of alkaline hot and cold water rinse tanks and attendant forced circulation drying on a 1200 amp. installation. A DuPont electrolytic copper plating setup adequately covers Adel needs in protective coatings in carburization processing or for "de-carb" control in hydrogen brazing. This system is also employed in the protection of processing, in certain heat-treated dies and fixtures, this technique having been found particularly advantageous in increasing life of punches.

The DuPont tin plating unit, together with standard cadmium and silver plating equipment, complete the Adel protective coating facilities. Due to WPB restrictions, chromium plating is accomplished by outside vendors.

Existence of such equipment as electrolytic etch tanks, Bullard-Dunn processing units, hot and cold alkaline washes assure adequate metal cleaning. Complete nitric acid passivation systems are installed, since such a high number of Adel parts are fabricated from 416 and 440 stainless steels.

Adel has carried out special studies on tool contour and has widely investigated specific metal machinabilities (with particular relation to N.E. steels) to accomplish improvements in production. Currently, step down tests on incoming fabricated materials are being more carefully scrutinized. This metallurgical technique involves shapes, castings and forgings; particularly where cracks, seams, inclusion patterns, porosity or localized hardness areas and segregations could affect uniformity, usability and consequent acceptability of incoming stock.

Adel has found, after comprehensive investigation in cooperation with nationally known lubricant vendors, and as applied to the machining of annealed 440C stainless (255 Brinell max.) that a sulphurized-chlorinated, light transparent hydrocarbon lubricant, with saponifiables added, is the best solution, in fabricating this tough machining metal. It is general Adel practice to employ carbide tipped tools when machining type 416, particularly in the 35 to 42 Rc. range.

These are a few of the many considerations which have won Adel its prestige in quality control and has made it a leading national producer of hydraulic systems.

**A Materials Article** Developed for a strictly wartime application, blackened stainless steel is in effect a new material to challenge the interest of any designer looking for a strong, tough and black metal that is at the same time corrosion-resistant throughout its section. Mr. Strassburger describes herein the nature and characteristics of the material and outlines its present and potential applications.

# Blackened Stainless Steels

### by PERRY B. STRASSBURGER

GETTING A NEW PROCESS out of the laboratory and into the field is a big job even in peace times. But when an invention calls for wide experimentation in the domestic field, the first reaction of the engineers who may be held responsible for unsuccessful applications is to wait until test after test under widely varied usages have proved beyond all doubt that under all conditions and under every abuse the new development will work perfectly. However, the intriguing possibilities of the new process for blackening stainless steels developed by the Rustless Iron & Steel Corp., have prompted this preliminary discussion—not that any universal claims may be asserted now but rather that here is a new idea which may be most useful in many other fields than those which have already appeared.

At the outset it should be made clear that Rustless is not interested in selling either the equipment or the materials used in its blackening process. The process is patented and a simple licensing arrangement is ready for users of this process at a very low fee. No license is required for experimental work—on the contrary processors are invited to use the facilities of the developers without charge for blackening of samples.

## Characteristics of the Blackened Metal

The most conspicuous thing about the stainless steels and the feature which usually appeals first to the designer and the customer is their permanent lustre. However, in certain cases this very quality is not permissible. For instance, in the Garand (M-1) rifle reflections of light would betray the most perfectly camouflaged soldier. Yet the corrosion resistance of type 416, 12% Cr, free-machining stainless steel, for this particular job as well as its high heat-resistant abilities in certain parts in this assembly are invaluable. To meet needs of this sort the new method discussed in this article was developed. It not only blackens the metal with a durable finish but also gilds the lily when it slightly improves even the well-known corrosion defiance of the surface of the stainless steels.

In developing this material and method Rustless engineers and metallurgists first set up their desiderata: (1) The color must stick on; (2) it must cause no reduction in corrosion resistance and possibly increase this vital factor; (3) it must be thin and must not change the dimensions of a precision part; (4) the abrasion resistance must be kept as high as possible to prevent the coating from easily rubbing off; (5) the coating must be ductile; and (6) the blackened skin must not suffer in service from high temperatures in any greater degree than the stainless steels before treatment.

That these desiderata were substantially met has been shown in exhaustive tests both at the home plant in Baltimore and at the Springfield Armory, makers of the Garand rifle. Not only did this development attain all of these goals but it also exceeded the technicians' fondest hopes by somewhat improving on the established resistance to several corrosive media by the stainless steels so treated. In the Table are given the results of tests, again on the same three widely-used alloys charted for operational time in Fig. 1.

Many engineers are now thinking in broad terms about the peacetime usages of this new 0.00001 in. thick coating, checking the commercial feasibility and possibilities of the black surface, so that when the proper time comes the field work will be well advanced.

## Applications: War and Postwar

It is not on land alone in the Army's Garand rifle that the blackening process has been applied. It is also in use by the Navy at sea and will likely be seen in the air since laboratory tests at Sperry Gyroscope Co. have proven satisfactory. The severe conditions

*Four of the 36 blackened stainless steel parts in the Bludworth depth sounder.*

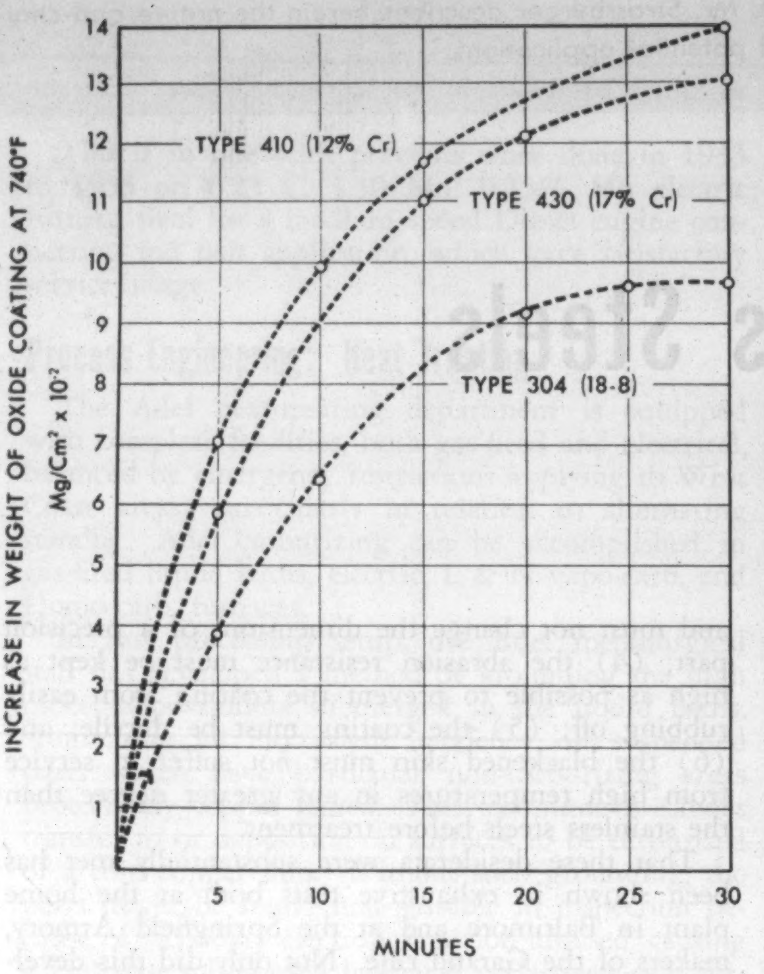
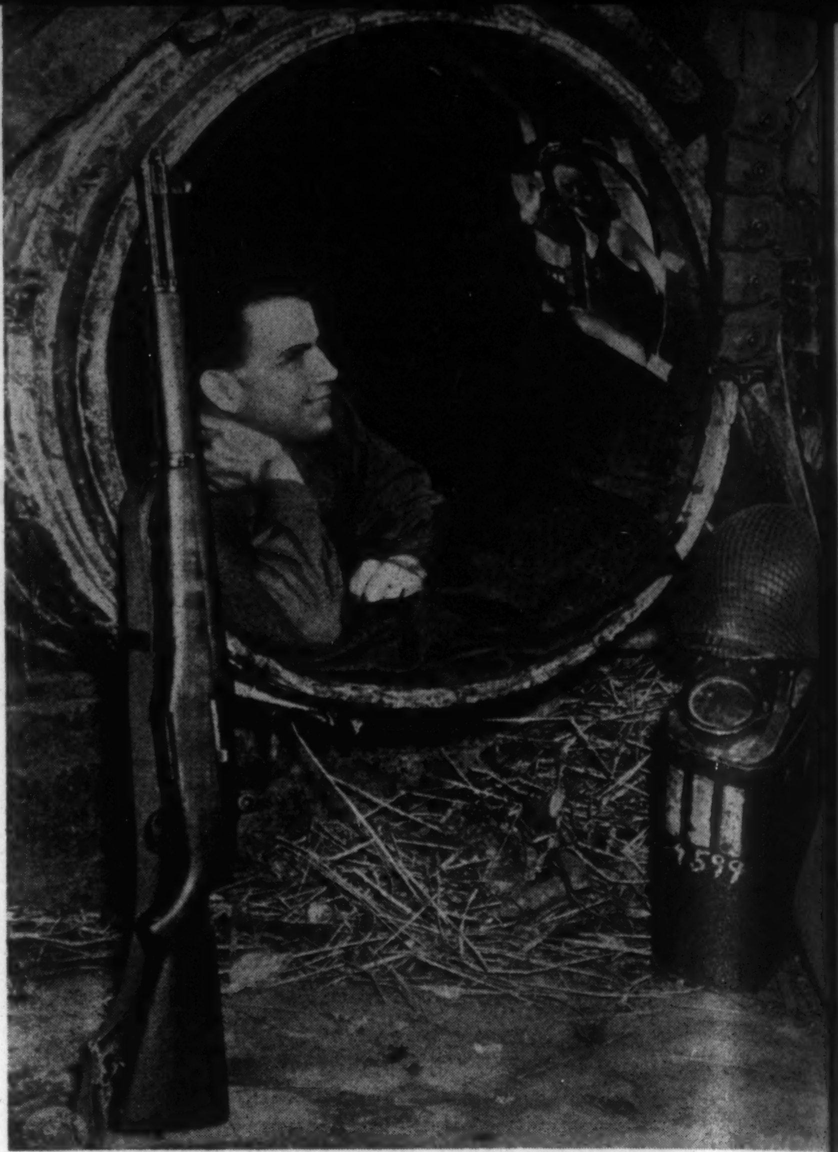


*Fig. 1. Rate of coating formation in the molten dichromate bath used for blackening stainless steels.*



*In this interesting picture from France, the M-1 (Garand) rifle with its blackened stainless steel gas-chamber right under the muzzle is clearly shown.*

under which the finish of blackened stainless steels has survived on three dozen components of the Bludworth Depth Sounder, developed by the International Projector Corp., are worthy of careful study. Without going into details of the construction of this device, it is sufficient to state that inboard and outboard applications of blackened stainless steels have been passed by the Navy engineers and have served in all of the seven seas without failure. In this service the blackened stainless steels are subjected to five abuses: (1) salt spray; (2) submersion in sea water; (3) alternate submersion in sea water and air; (4) tropical sunlight; (5) rough handling at dockside and on board—the equipment is portable.

Examination of test equipment in use for over six months under grueling tests showed the blackened stainless, both 18-8 and 12% Cr, to have resisted corrosion completely. Further it showed that under trying abrasion conditions such as on a lashing-post, the loss of color did not result in shine but rather in a dull glint which did not reflect light to a noticeable degree. Parts not subjected to severe abrasion showed no color change when compared with new parts.

Not that this need for blackening the stainless steels is merely a war-born necessity—for a rather large group of peace-time applications has shown the need for dulling the finish of the stainless steels. In many products, especially those made from wire, bars and forgings, the principal reason for using stainless steels is not their lustre, but their high strength properties and special magnetic or electrical characteristics coupled with corrosion and heat resistance. Some potential applications might be oven tops, typewriter and adding machine parts, springs, windshield wipers, valves, camera parts and other items requiring all black or partially blackened surfaces. In many peace-time usages this method might have a profound effect not only on the mechanical design but also on the aesthetic design of metal products.

For example, consider the appeal to designers of molding, trim, bolt heads, screws, corners or decorative sheet cut-outs of blackened stainless steel if in future field-tests under practical usages they retain all the basic, versatile qualities which these strong corrosion and heat-resisting alloys possess. Its use for structural ornament outdoors as a contrast material to polished stainless steel should prove exciting to new-school architects. The materials remain for all practical purposes identically resistant to corrosion so that bright raised surfaces will not be affected by blackened recesses immediately adjacent. Nor will galvanic action between bright and blackened stainless steels need to be considered. The solution potential of both surfaces has been measured and the difference is negligible.

A vogue of black jewelry began in Paris before 1900. The medium was known as gunmetal. It had gorgeous color texture. But it tarnished quickly and soon lost its beauty. Worse than that, it spoiled white gloves and stained garments. Now that American wristwatch cases are fabricated of stainless steel, suggested potential developments akin to this field include other jewelry applications. These trades have advanced these and other items as peace-time probabilities. Other uses might include nails, screws and motion-picture projectors and sound equipment, as well as dark-room photographic equipment—all classic examples of the plague of rust. Few, if any, have been widely experimented with, as yet.

When a designer today thinks of peace-time applications of the stainless steels, or as a matter of fact any of the metals or other basic materials which have so greatly extended their usages during and as a result of the war, he will take into consideration the lessons learned about climate far and beyond our own land. Many a bitter pill has been swallowed by manufacturers of impeccable standing and ability by the failure of their products in the tropical and sub-tropical lands of rain, salt atmosphere, constant humidity, fog, mud, slime, coral rock, volcanic cinder, mold, insects and organisms. Much of the same ruinous effect occurs equally under arctic conditions.

That this blackening process seems actually to improve the corrosion resistance is a factor of importance to every designer. When the men come back they will confirm the efficacy of the blackened gas cylinder right below the muzzle of their Garands. No scientist could devise a "torture room" for testing compared with that of placing millions of test parts right at the muzzle of the Army rifle, distributing them in as many different hands, in all parts of the world and subject the part and the finish of the part to rapid-fire, high-head, corroding explosion gases and climatic exposure of desert wind-swept sands and surf-swept beaches in landing operations.

Too much cannot be said on the startling deterioration of military equipment under tropical conditions. Here is packed in the very briefest time obsolescence which might take years and years of ordinary wear. Under extreme conditions, a first-class pair of shoes may be useless in several days—to say nothing of articles made of metals.

## Development and Nature of the Process

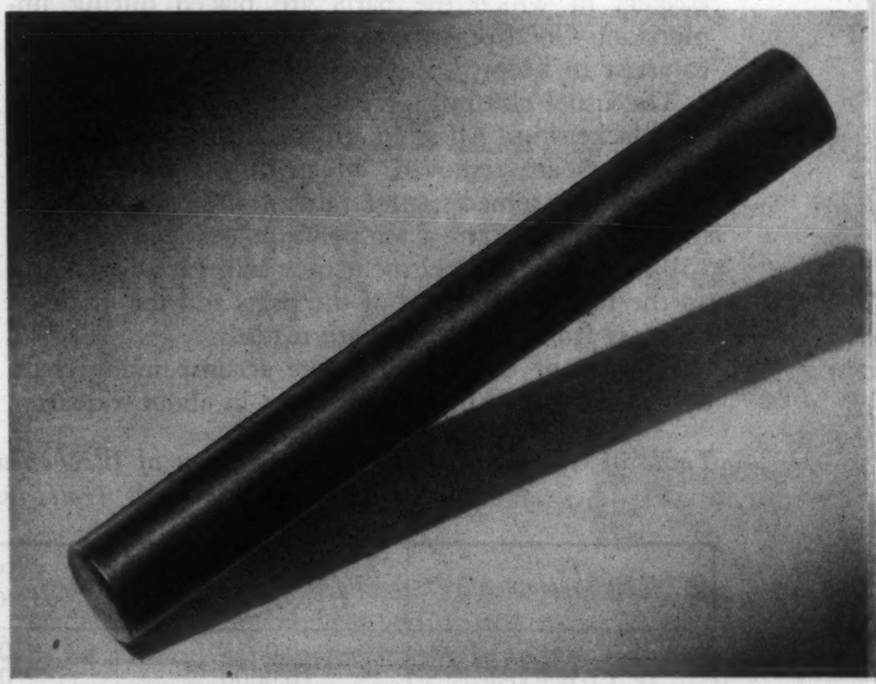
The problems presented by previous blackening methods have been set forth by W. R. Meyer in a paper printed in the *Proceedings* of the American Electroplaters' Society in 1943. In the industrial field some manufacturers have used pigments, enamels, japans, electroplated coatings, flame and temper staining. All of these methods have been faulty in one way or another when applied to stainless steels. Failures have followed owing to brittleness, poor adhesion, low resistance to abrasion or, most seriously, deteriorated corrosion resistance.

In theory, a thin invisible film of oxides, chromium, iron and nickel, gathers on the surfaces of the stainless steels. It is the stability of this film which gives the measure of the corrosion resistance. There is a marked enrichment of chromium in the film as compared with the underlying steel and this enrichment increases in relation to the percentage of chromium in the alloy and with the degree of polish.

This is true of the entire group of alloys popularly known as stainless steels. Strip these oxides away with chemicals and the oxide film re-forms instantly to continue its protective action as soon as it is again in contact with oxygen in the air or some oxidizing condition. Go after this film with hammer and tongs—machine it away, file it off, peen it down into the metal. Back it comes again. This is the phenomenon that makes it difficult to apply coatings as most people think of coatings to the stainless steels. *They don't want to stick because of the natural coating that got there first!*

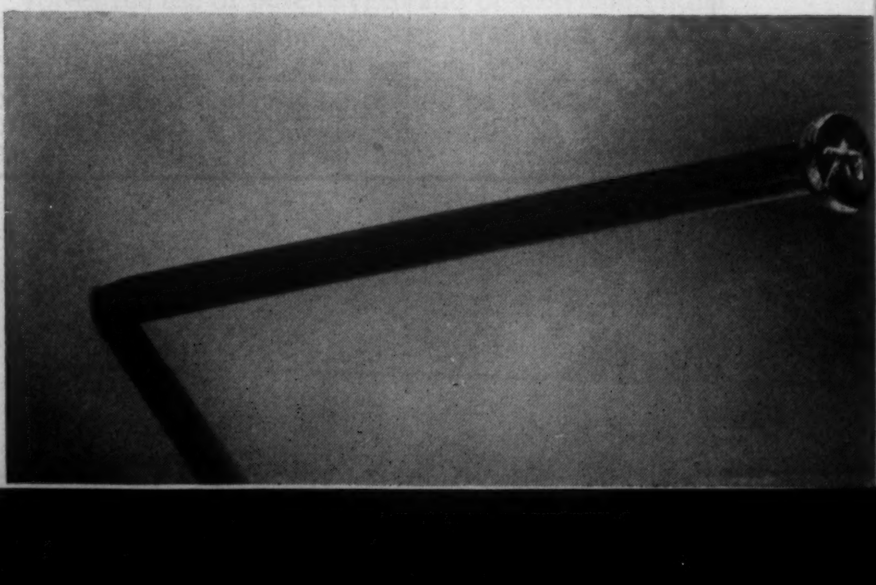
*Blackened stainless steel gas-chamber as shown in the picture of the soldier. Inset shows figure-8-shaped stainless steel bar-stock from which the part is made.*

To shift the oxides of the surface film of stainless steels so as to change color and brightness to another color with reduced reflectivity presented a trying problem due to the very complexity of the oxide components. The method is limited to electrochemical or chemical means. Starting on such a problem, the chemists and metallurgists were confronted with a seemingly-endless chain of varying oxides and countless combinations of oxides. To determine just how to attain this selective oxidation called for patience and imagination.



*Typical test bar from Rustless laboratories.*

*Whimsical test application for blackening stainless steel nails which may have some real merit.*



First guess is to burn on an oxide film in a high temperature controlled atmosphere. Yes, you can change the color of the stainless steels. In certain types of oxidizing atmospheres you can readily cause an alteration in the chemical make-up of the oxide film at high temperatures. As a matter of fact, if you were persistent enough and applied enough heat for a long period you could shift the entire alloy into the oxides of its elements—with a complete loss of its virtue. But if you stopped this process at an intermediate point, you would have effected an apparently successful color change. But it doesn't work out that way. By this all too obvious method you would have produced nothing but a porous, brittle oxide which can readily be penetrated with a number of corrosive media—in fact, you would have practically destroyed the corrosion resistance of stainless steels to most media.

The new black coating as finally developed is formed in a non-aqueous bath at moderately high temperature. Thus it is an oxide of the metal and not a hydroxide. This is the reason for its endurance when exposed to heat and atmospheric changes. Not only does the blackening show no tendency to turn gray but also upon microscopic examination after over a year's exposure to all the galaxy of fumes and gases of a research laboratory, no alteration was visible.

To attain all of the desirable features of this blackening process calls for very little equipment. All the fabricator needs is a steel tank of suitable size, an adequate method of heating and some holders or baskets in which the parts are placed during immersion. Good practice calls for a cover and a stirrer to assist in keeping the coating uniform.

The usual cleaning of parts to be treated precedes the blackening. All scale, grease, oil or other foreign substances are removed. Meanwhile a molten solution of dichromates, preferably sodium dichromate, should be raised to a temperature between 730 and 750 F. Naturally, treatment time will vary depending on the number and size of the parts and the grade of stainless from which they are made.

A study of the curves in the accompanying chart will show that stabilization occurs in about a quarter hour. The chart gives curves for three of the most popular types of the stainless steels. Parts are then removed from the hot bath, allowed to cool to room temperature and rinsed in hot water. The salts are readily soluble and it is simple to remove them. Dry with air-hose and the parts are ready for service.

The use of oils and waxes to improve the lustre of the black finish has been found successful. This is a regular practice with black coatings on ordinary steels, but for the purpose of protection from rusting more than obtaining a lustre. Some engineers claim that black-oxide-finished ordinary steels have no corrosion resistance when the oil or wax impregnation disappears. Of course this is not true with blackened stainless steels for they remain highly resistant to attack even if the black oxide is removed.

## A Glance Ahead

Under a competitive economy there will always be a cheaper way to make an article, but for that class of metal parts in devices which must have a high degree of permanence, the stainless steels—blackened or bright—have come through the war experiences with greatly widened acceptance. Projected peacetime usages will include products requiring high corrosion and heat resistance, stratospheric-cold toughness, non-magnetic properties and great strength-weight ratio—as for aircraft, automobile and railroad components. Also surgical instruments, office machines, textile accessories, counting devices, marine hardware, fittings, ship tackle, jewelry and numerous others. With the impulse that nothing can be too good for our forces on land, sea and air, the Armed Forces have hurdled the barrier of a little higher material cost. Stainless steels sell at actually lower cost differentials when performance, permanence and appearance are being purchased.

The technique of handling all stainless steels in the shop has been given wide-spread development. Now that a black-finished stainless surface is available the forward-thinking designer may find it much to his credit to investigate this new process not alone for the color value but also to prove to himself the added merit of greater endurance.

*Table of Comparison of Corrosion Rates of Blackened and of Untreated Stainless Steels in Weak Nitric and Hydrochloric Acids (rates expressed in grams/cm²/50 hrs.).*

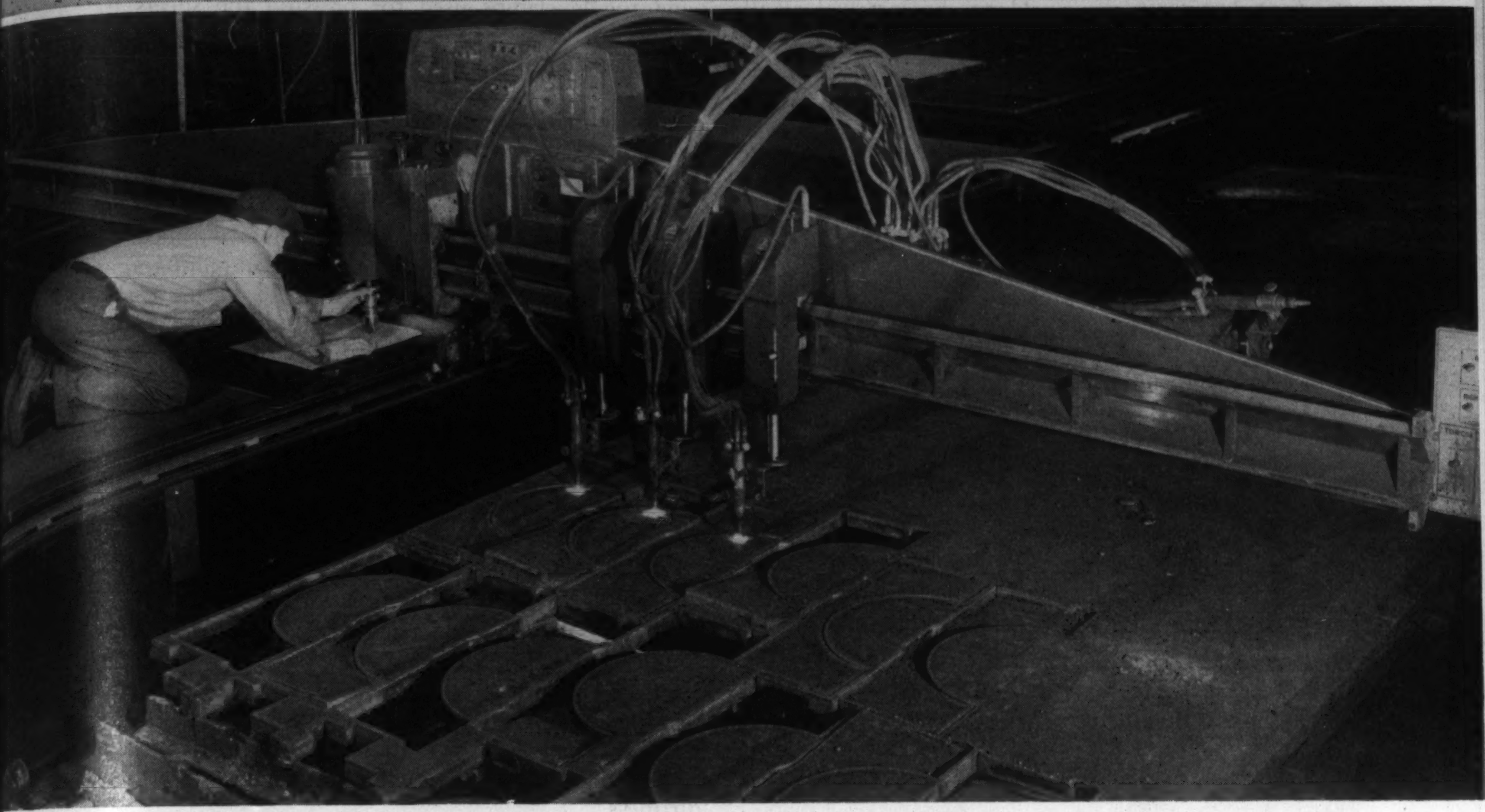
| Test Specimens* | 0.5% by wt. $HNO_3$-boiling | 2.5% by wt. $HNO_3$-boiling | 0.5% by wt. HCL-120°F. | 1% by wt. HCL-120°F. |
|---|---|---|---|---|
| 12 Cr | 0.0023 | 0.104 | 0.993 | 1.480 |
| 12 Cr-Blackened | 0.0000 | 0.008 | 0.108 | 0.473 |
| 17 Cr | 0.0008 | 0.0004 | 2.72 | 2.940 |
| 17 Cr-Blackened | 0.000 | 0.0000 | 0.0505 | 0.882 |
| 18-8 | 0.0012 | 0.0000 | 0.0193 | 0.0190 |
| 18-8-Blackened | 0.0000 | 0.0000 | 0.0007 | 0.0012 |

* Test specimens were 2 in. x 1 in. x .050 in., with a pickled finish.

*Chemical Analysis of Steels Tested*

| Type | C | Mn | P | S | Si | Cr | Ni |
|---|---|---|---|---|---|---|---|
| 12 Cr | 0.11 | 0.43 | 0.015 | 0.024 | 0.35 | 12.17 | 0.18 |
| 17 Cr | 0.10 | 0.47 | 0.018 | 0.017 | 0.36 | 17.48 | 0.12 |
| 18-8 | 0.05 | 0.65 | 0.021 | 0.015 | 0.54 | 18.11 | 9.18 |

**A Methods Article** The use of the oxyacetylene flame for metal-cutting has expanded considerably during the war, but is still less than its actual advantages, if more widely appreciated, would compel. In this article Mr. Cady discusses several practical considerations, attention to which can improve the effectiveness of flame cutting and flame machining and also notably broaden their utility in any metal-working plant.



*A multi-torch flame cutting machine, which follows a template or drawing on the pantograph principle in slicing through heavy steel plate.*

# Flame Cutting and Machining Methods

### by EDWIN LAIRD CADY

JUST BEFORE THE WAR the art of flame cutting in machine shops, welderies, foundries and steel mills was making the most rapid strides in its history. It was growing in adaptability, accuracy, overall rapidity and economy.

Progress has been accelerated during the war. But in common with all metal fabricating arts, flame cutting has a serious problem. The costs of materials handling, of work preparation and of work positioning, may be anywhere from one to ten or more times the cost of the cutting operation itself. And in the operating time cycle—the "floor-to-floor" or the "from one operation to the next operation" production time—the actual time needed for cutting may amount to very little; most of the minutes and seconds being devoted to getting the material ready to be cut and getting the finished product on to the next operation. In the preparation of the edges of one ship plate for welding, for example, the complete floor-to-floor time is 35 min. of which only 7 min. are devoted to flame cutting.

Flame cutting has an additional handicap. It involves the use of pure oxygen and of acetylene (other gases such as propane are sometimes substituted for the acetylene where they are available at low cost). Therefore flame cutting cannot be installed at will wherever space happens to be available, or when its logical place happens to be in a production line.

In fact, flame cutting should not be installed at all in any location:

Where an open flame would be a fire hazard.

Where the sparks from the process would be a fire or personnel hazard.

Where ventilation is inadequate. This applies especially if metals coated with zinc, lead or other dangerous fumes producing materials are to be cut.

Where oil, grease, or other material, which becomes unusually fire hazardous if exposed to pure oxygen, is likely to become loaded with oxygen which escapes from the process.

Where dangerous gas containers, hoses and control devices, are subject to mechanical damage or other harm from nearby equipment, or cannot be stored and handled with safety.

Where the bright light, the flames and the drama of the flame cutting process will be too much of a distraction to employees working at other tasks; the heat from the process will cause danger or discomfort to those employees.

These restrictions have led to flame cutting being used more widely in plants having welding departments or foundries, in steel mills, etc., and in others having special spaces in which the necessary conditions are present, than in the general run of machine shops. But many more plants could profit by setting up facilities for flame cutting. The handicaps are challenges to production engineers.

## Good Housekeeping Needed

Traditionally, a high percentage of flame cutting operations have been such that attention to keeping abrasive or other non inflammable soils off from the work or away from the work place was a minor consideration. The cutting of sprues from castings, reducing of steel scrap to sizes suitable for charging into cupolas, or whittling out rough steel shapes for structural members, are examples of this work. Single steel plates could be taken to a room no better kept than an old time foundry, and with a little wire brushing to remove surface scale, be flame cut to size for welding with complete satisfaction.

Such work lent itself to the idea that a plant which already had a well ventilated and fire resistant but rough and dirty room was in the best position to make use of flame cutting. Furthermore, such operations commonly were original or very close to the original ones performed on raw materials. The materials to be flame cut could be taken directly from the foundry flasks or from the steel storage room to the flame cutting operation, then could be given a cleaning that would fit them for the production line after the flame cutting was completed. Very seldom was work taken from the machine shop or the production line to the flame cutting process and then brought back for further machining.

In contrast to this, much of modern flame cutting requires clean quarters and the best of housekeeping. In the stack cutting of steel sheets, for example, an air space as much as 0.003 in. thick between any two of the sheets may cause the cut to be lost and the work to be spoiled. A slight amount of soil getting into the pile of sheets can cause wider spaces than this to be formed. And the presses, hydraulic rams and toggle clamps used for pressing the sheets together to squeeze out any air gaps caused by inequalities in the sheet surfaces and for holding the sheets while the sheet edges are bead welded to hold them tightly together for cutting, all can be defeated in accuracy or subjected to severe maintenance problems if abrasive dusts are present in the rooms where they operate.

Much of modern flame cutting is controlled by highly accurate machine guides, ways, pantographs and the like. Within the limits held in most machining operations (but not in grinding or lapping operations) machine controlled flame cuts can be as accurate as the guides hold them. Ordinary limits of the cutting accuracy of the flame itself, if perfectly guided, are:

| Mild steel, not over 0.35% C: | |
|---|---|
| Stock to 1 in. thick | plus or minus 0.003 in. |
| Stock to 2 in. thick | plus or minus 0.010 in. |
| Stock to 4 in. thick | plus or minus 0.0175 in. |
| Stock to 6 in. thick | plus or minus 0.0312 in. |

On many operations such as the production of hydraulic press members from heavy plate, higher accuracies than these are being held. Machine type control devices are as readily damaged by poor housekeeping when a flame is doing the cutting as when a steel bit is the cutting tool. Accuracy is destroyed by dirtiness.

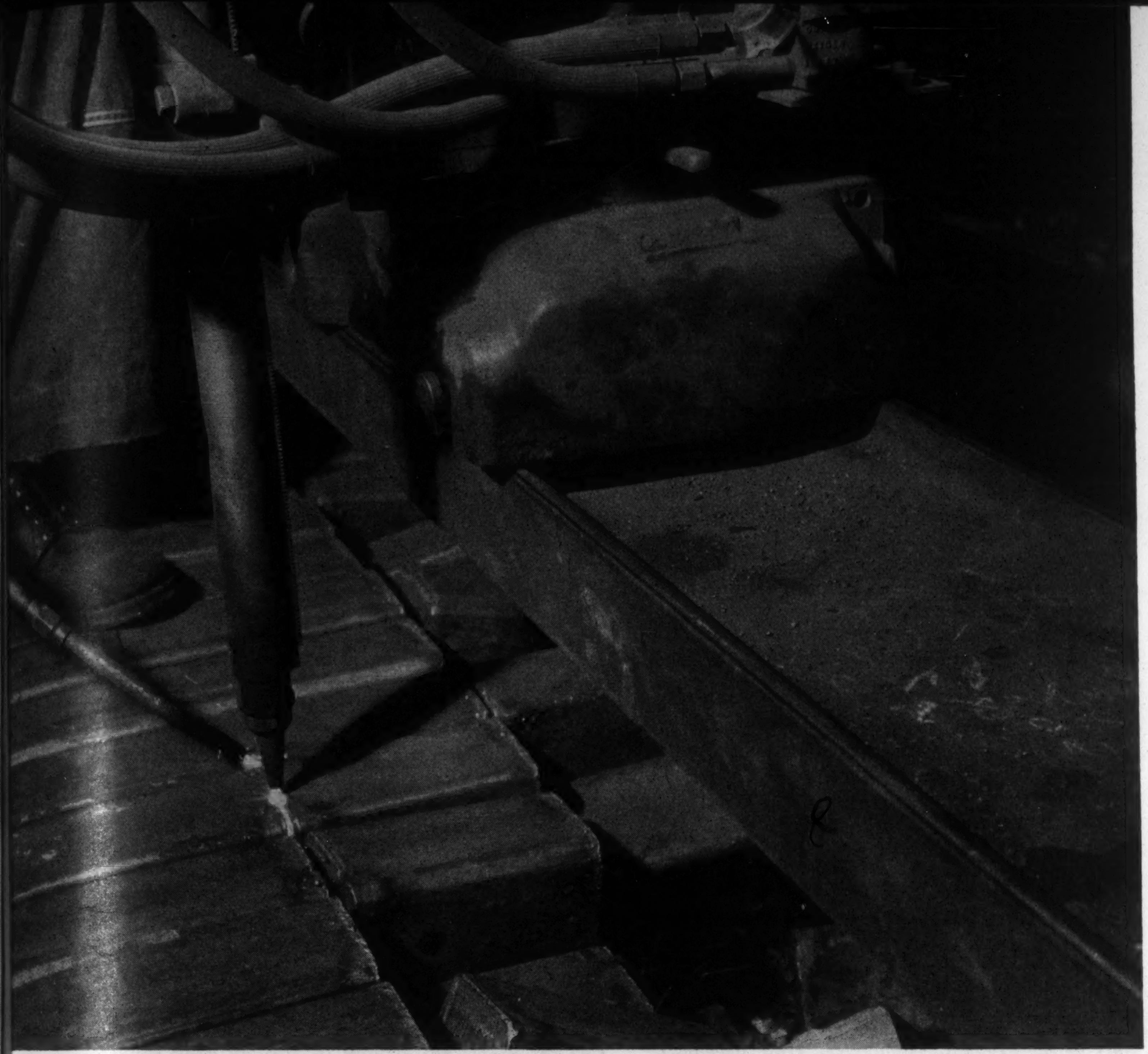
These operations which require clean conditions, bring flame cutting into the mental pattern of the methods engineer who is used to doing everything in clean, carefully kept surroundings. They are responsible for much of the ever widening use of flame cutting by machinery manufacturers.

A flame cutting room then becomes one more walled-off or partially walled-off department on the regular production floor, and is no more isolated nor "special" than the lacquering or the finishing room. Work in process is transferred to it by monorail, lift truck or other ordinary materials handling means and is similarly carried back to the main production line. A mechanical rubber products maker has such a room to produce steel backing and reinforcing members for friction discs and other products. A pressed steel shop has a flame cutting room "in the line" for bevel cutting the edges of dished heads and other pressed shapes in preparation for welding.

## Flame Cutting Procedure

When completely severing a piece of metal, the blow pipe is usually held at an angle of nearly 90 deg. with the surface of the work, in the plane in which the cut is to progress. If a square cut is to be made, the angle also will be 90 deg. in all other planes; the direction of the stream of oxygen thus is nearly vertical to the plate surface. Bevel or other angle cuts can be made by holding the blow pipe at an angle other than vertical to the surface of the plate. The direction of the cut will be the same as that of the stream of oxygen.

The cut can be made to go much faster through steel plate, by inclining the blow pipe so it is at an



*Shell forging blanks are cut from steel bars by oxy-acetylene cutting machines, preceded by a preheating flame from a manually operated blowpipe. Each 6-in. long square blank will make one shell.*

acute angle with the plate in the plane in which the cutting is to progress. If done with a single blow pipe, this produces a cut surface far too rough for most commercial use. But if a second blow pipe follows close behind the first—the traditional "roughing cut then a smoothing cut" principle of metal working—then the accuracy can be maintained at top limits while the overall speed is doubled. In one shipyard application, a single nozzle cut a ½-in. plate at the speed of 18 in. per min., while with two nozzles, the leading one being given the acute angle or "leading drag" and the second a straight vertical angle for highest accuracy, the speed was doubled to 36 in. per min.

The practical economics of such an increase in speed carry flame cutting into the realm of careful production control and subject it to the same types of costs analyses that would be used for lathes or planers. This kind of cutting amounts to a lot more than just having a blow pipe with a man who knows how to run it.

## Positioning and Other Control

First of all, the selecting of nozzles must be very carefully done. The pre-heating and post-heating flames must do their work with maximum speed of cut but minimum distortion of the steel and use of the gases. Heat accumulation in the metal is cumulative to some extent; the longer the cut the greater the trouble. In most cases the distortion can be kept within the bounds of the required accuracy of work by keeping the work clamped in place while heating and while cooling to room temperature, or by water quenching to cool, or by allowing a distortion factor when originally planning the job.

In other cases the spot heating of the work with oxy-acetylene flames will remove the distortion (a technique also used after all kinds of welding). Stock ½ in. thick or thicker, distorts little or none at all, because the mass of the metal provides enough rigidity to resist distortion unless long and narrow pieces are to be cut off. Nevertheless, the primary method of eliminating distortion troubles is the correct selection and use of nozzles.

Second—is the correct positioning of each flame in relation to the work and to the other. If a nozzle is too close to the work, slag may be spattered into it, reducing its accuracy and setting up a maintenance problem. Accuracy of the cutting action of the flame itself is almost wholly a function of the accuracy of the oxygen passage in the blow pipe; if this accuracy is temporarily impaired by slag and permanently impaired by the maintenance procedure in removing the slag, then the accuracy of the cutting is reduced accordingly. The distance the nozzle is held from the work affects the character as well as the accuracy of the cut; in spite of any inequalities in the surface of the plate neither nozzle may ever be too close or too far away.

The exact positioning of the flames in relation to each other must prevent them from ever interfering or "fouling," yet must permit the second or trimming flame to take advantage of the preheating effect of the first. This is important because nearly all flame cutting is promoted in smoothness and accuracy as well as speed by preheating of the metal to be cut. Once the leading flame has created this preheat during its cutting action, the following flame must take full advantage before the heat is conducted away by the metal. By maintaining the best practical "heat balance" between the two flames, the total amount of heat imparted to the main body of the metal is kept at a minimum while the work is done at the highest speed and with the greatest accuracy.

Third—is the selecting of the means for keeping the nozzles at their exact distances from, and angles with, the metal. If the metal is perfectly flat, or can be clamped flat and held so during the cutting, then this positioning of the nozzles is done in the same way as with any machine tool; the work or the nozzle (whichever is to be stationary) is held in fixed and known position, and the other is swung or moved on an arm, suspended from a gantry, or controlled by any simple mechanical motion. But if the plate is too heavy to be clamped perfectly flat, or is intended to have a curved or other non-flat surface, then the nozzles must be made to follow that surface exactly.

On long surfaces such as ship plates the nozzles are commonly supported on carriages or "follower rolls" which ride directly upon the plate surface and, by the use of linkage, cause the nozzles to keep at the right distances from the plates no matter what may be the plate surface contours. Often these rolls must be water cooled or water shielded to protect them against the heat of the cutting operation, and this introduces further mechanical complexity into the equipment.

Fourth—is the multiple cutting of single edges. By varying the angle of the nozzle to the work in a plane other than that of the direction of the progress of the cut, the flame will make bevel or other angle cuts. Sometimes two bevels—one on each side of the plate—are wanted. Combined with the bevels may be a right angle cut called a "nose" to be in the middle of the cut edge; two such sheets when abutted present two "V"s in which butt welds can be made with far less time and rod expenditure than would be needed for a single large "V" extending the complete width of the plate. The two "V"s require that two beveling and one right angle cut be made on the same plate. All three cuts can be made by the simultaneous passage of three grouped nozzles along the edge of the plate.

In any multiple cutting, problems like those of the two flame cutting of a single right angle cut must be solved. Flames must not be allowed to foul each other; one flame must make all possible use of the preheat generated by another; the steel must be clamped flat or else the nozzles compelled to follow its contours.

Fifth—is the usual production problem of balancing the employment of floor space against the costs of materials handling, production equipment, labor, supplies, etc., with heavy emphasis on set-up costs.

In one shop there was plenty of available floor space, minor need for production. Steel plates about 30 ft. long by 8 ft. wide had to have all four edges prepared for welding. Lining up several plates on supports along the floor, clamping steel tracks along the four edges of one plate at a time, taking the portable flame cutting machine to the clamped plate and running it along one track at a time so as to trim one edge at a time, permitted the preparation of about five plates per day.

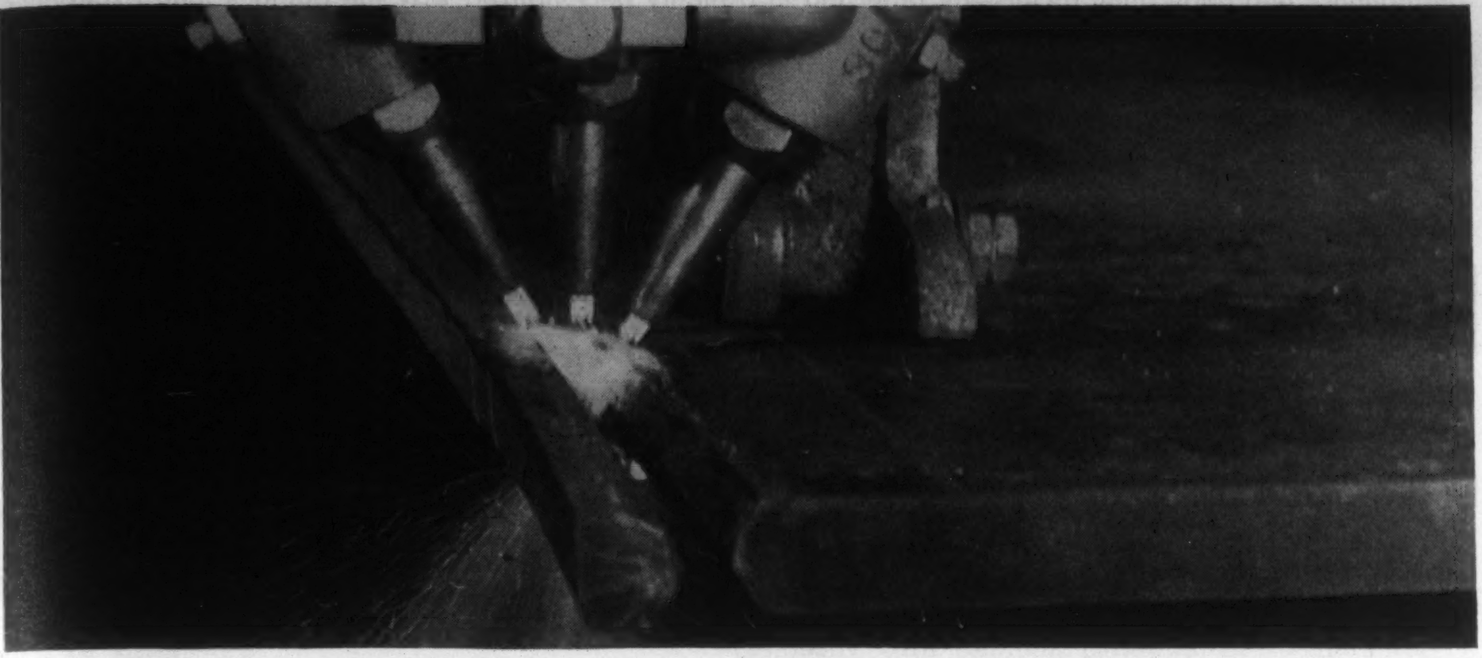
With need for production increasing and floor space more in demand, an "L" shaped supporting stand was erected. The shop crane would place one plate on this, the portable machine would prepare two of the plate edges (one lengthwise and one crosswise), then the crane would lift the sheet and turn it end for end and the other two edges would be prepared. The shop crane then lifted the sheet from the stand and carried it to the storage pile. Production by this method doubled to about 10 plates per day, with floor space about at its minimum for the job.

Still more production being needed, a gantry support for two cutting nozzles was erected. With this the two long edges of the plates could be flame cut at one time, then the two short edges. Since the plate did not have to be lifted and turned end for end, only two crane lifts were required instead of the previous three. Nevertheless the crane was busier than ever on general shop work, and enough time was lost in waiting for the crane to limit the output to 18 plates per day.

The problem of further increasing overall production, then, became more of increasing materials handling speed than of cutting speed. And this situation is quite common in the shops which have made the most extensive use of flame cutting.

## Flame Machining

Similar methods problems are found in flame machining. Flame machining is distinguished from flame cutting in that machining is intended to remove metal from the main body but not to sever that body, while cutting is intended to sever the main body of metal. The employment of these terms varies from shop to shop and even within the same shop, but nobody who knows the difference between



*Trim cutting of plate edges prior to welding them is done with a 3-in-1 unit.*

a forming tool and a cutting off tool as used in a lathe will have any trouble in getting the general idea.

For flame machining the blow pipe cutting head is held at an acute angle to the surface of the work, this angle ranging from about 5 deg. to very nearly tangential. The oxygen orifice is larger than for removing the same amount of metal by cutting, the oxygen pressure is lower and the oxygen stream more expanding. As a result, the flame cuts a groove in the surface of the metal rather than penetrating clear through the metal. The depth and contour of this groove can be controlled to close limits.

By employing heads in series or in tandem, or cutting successions of grooves with one head and then making clean up cuts to remove the ridges left between the grooves, many rough operations similar to much of the work done on conventional metal planers, shapers, millers, lathes and boring machines can be performed. The type of operation generally is designated by the conventional metal cutting method for performing it. Examples are "flame planing," "flame turning," "flame spinning" and "flame milling."

The advantages of this process are that it can hog off metal three to five times faster than ordinary metal cutting machines, it requires neither the power to cause a metal tool to do mechanical violence to the main body of the metal nor the machine strength and rigidity to hold the tool and metal in place while this power is expended, and that it works better on high carbon or "hard" steel than on low carbon. The disadvantages are in lack of accuracy of finish—flame machining accuracies never are as high as those of fine lathe work—and that neither engineers nor machine operators who understand this work are so plentiful as for conventional machining.

A tank manufacturer required dished heads to be welded to tank bodies. The welds were to be made in "U" shaped abutting grooves instead of the ordinary "V" grooves. Flame planing (running the blow pipe along the plate edge as a conventional planer tool would operate) cut the "J" or "half U" grooves in the plate edges. These grooves, when the edges were abutted for welding, would form the full "U"s.

Cutting similar grooves in the edges of the dished heads by ordinary lathe methods, would have needed a lathe of large swing, with the cutting speed held down until the cutting pressure was not great enough to cause spring action in the heads. But by the flame turning method, the heads were clamped to simple spindles and rotated against a stationary cutting nozzle. The equipment needed was far less, and the set-up time negligible as compared to that for a lathe. If high enough production had been needed, two or more cutting heads could have been applied at once to evenly spaced areas of the periphery, thus reducing the cutting time without increasing either the power required or the complexity of the set up.

Conveyor links used under highly abrasive conditions had too short lives. The usual custom was to repair old ones by hard surfacing. New links were stack cut out of high carbon plate, then each one flame machined for bearings, guide pins and the like. The result was a conveyor of much longer life, since there had been wear surfaces on these links which were difficult to hard surface.

Much of flame machining of hard steels is assisted by preheating the steel to a point below its critical range—usually about 900 F. The advantages of this are higher cutting speeds, greater accuracy, more types of combination cuts or of shaped cuts, more control of the edge hardness at the cut, and fewer unequal stresses set up in the main body of the metal. These advantages come from the fact that the higher the temperature of the steel the greater its responsiveness to cutting, and the less the temperature difference between the cut and the main body of metal the less the temperature can effect the edge of the cut.

Like every other metals fabricating process, flame cutting creates some problems even as it solves others. But methods such as flame softening of heat hardened edges, etc., are enabling it to overcome its own problems, and to solve similar problems created by other processes. At its present stage of progress, flame cutting deserves far more attention from production and design engineers.

**A Materials Article** Electrical contacts are among the most important types of special metal parts and also among the least discussed in the technical press. Readers should therefore welcome this article on present development—trends and future probabilities in electrical contact materials as well as subsequent articles on performance and application factors—all reflecting in a highly personalized way the author's long experience in practical electrical-contact engineering.

# Electrical Contacts

## Part I—Possible and Actual Materials

by C. B. GWYN, JR.

*General Manager, Tungsten and Sintered Metals Div.,*
*The H. A. Wilson Co.*
*Newark, N. J.*

INTO THE DEVELOPMENT and application of the ubiquitous electrical contact has gone more intensive engineering of a comprehensive type—a combination of electrical, mechanical, metallurgical, design and production engineering—than most engineers realize. A piece of "copper," a precious metal tip, or "some kind of springy metal" is likely to be the average answer to a question about the nature of an electrical contact; yet the electrical contact in most cases has to meet a complex set of service conditions which most industrial parts escape, and their application-engineering and metallurgy are correspondingly complicated.

This article will take up one-by-one the metallic elements that can be or are being used as the major or important minor constituents of electrical contacts and will discuss the value and present application status of each. It will be followed by others (a) analyzing the causes of electrical contact failures and (b) selecting compositions and dimensions of contacts.

All are empirical in origin, personal in treatment and doubtless provocative. If they are productive of additional comment or research they will have thoroughly fulfilled the spirit in which they are written.

The following outline is intended as a partial summation only of results obtained from various elements and materials available for electrical contacting mediums and to promote further research and discussion along such lines.

Of all the elements which might be used successfully individually or in combination as electrical contacting elements, we find that from the practical standpoint of availability, performance, cost and ease of reproduction, we need only be concerned with the following:

Aluminum
Antimony
Beryllium
Bismuth
Boron
Cadmium
Calcium
Carbon
Chromium
Cobalt
Columbium
Copper
Germanium
Gold
Indium
Iridium
Iron
Lead
Lithium
Magnesium
Manganese
Mercury
Molybdenum
Nickel
Osmium
Palladium
Platinum
Rhenium
Rhodium
Ruthenium
Silver
Silicon
Tantalum
Thorium
Tin
Titanium
Tungsten
Vanadium
Zinc
Zirconium

Of these 40 elements the 14 which have been used most actively for contact purposes are—Aluminum, carbon, copper, gold, iridium, molybdenum, nickel, osmium, palladium, platinum, rhodium, ruthenium, silver and tungsten. The remaining elements listed above have proved advantageous only when combined with one or more of these 14. These will be regrouped and discussed in the rest of this article.

### The Most-Used Materials

*Aluminum:* As a pure metal aluminum is only used for contact purposes on large switch parts, such as knife switches, etc. Even for these uses it is often silver plated for protective purposes.

Silver alloys incorporating small amounts of aluminum have been tried out by the author without very favorable results, although there was some indication that the addition of small percentages of aluminum did increase the resistance to freezing (sticking). In the form of aluminum bronze, aluminum has occasionally been used for large circuit breakers, etc.; however, due to its tendency to oxidize or otherwise change its surface condition, this use has not expanded.

*Carbon:* Carbon in itself is often used for contact parts, where a large area can be used and where bulk is not a disadvantage. Under these circumstances a sufficient amount of contact area can be utilized to overcome inherent high resistance. It is normally used in circuit breakers, as the arcing tips on overload switches, etc. However, both copper and silver impregnated with carbon have shown to advantage for contact purposes. In addition, carbon with silver and nickel has shown to advantage where freezing of contact points is a problem and on some types of sliding contacts, such as in resistors, etc., the incorporation of carbon in the form of graphite has materially reduced the mechanical wear. In combination with tungsten and molybdenum (as carbides) it has shown to advantage, particularly when these carbides are incorporated with silver, copper, nickel, cobalt and several members of the platinum family.

It is believed that active contact research should include carbon, both as an impregnating medium for silver and silver alloys, also in the form of tungsten and molybdenum carbides. At the present time we are advocating such carbides and have had successful field test results for contact service on certain types of electric fence units, having high contact pressure and considerable impact on the contact points themselves during service operation. Also, these have shown to advantage as repeater circuit contacts on telegraphic and telephonic equipment and on equipment used in the transmission of pictures by wire.

*Copper:* In both a pure and alloyed form, copper is perhaps used for contact purposes to a greater extent than any other material, with the possible exception of silver.

At the present time we are primarily interested in copper as an alloying agent in combination with silver, and admixtures of copper and/or silver with tungsten and/or molybdenum, and/or their carbides. Copper incorporating age hardening elements is widely used as a contact material. This age hardening property frequently incorporates fractional percentages of silver, cobalt, vanadium and chromium as a hardening agent, the total percentage of all of these elements added being approximately 0.05%.

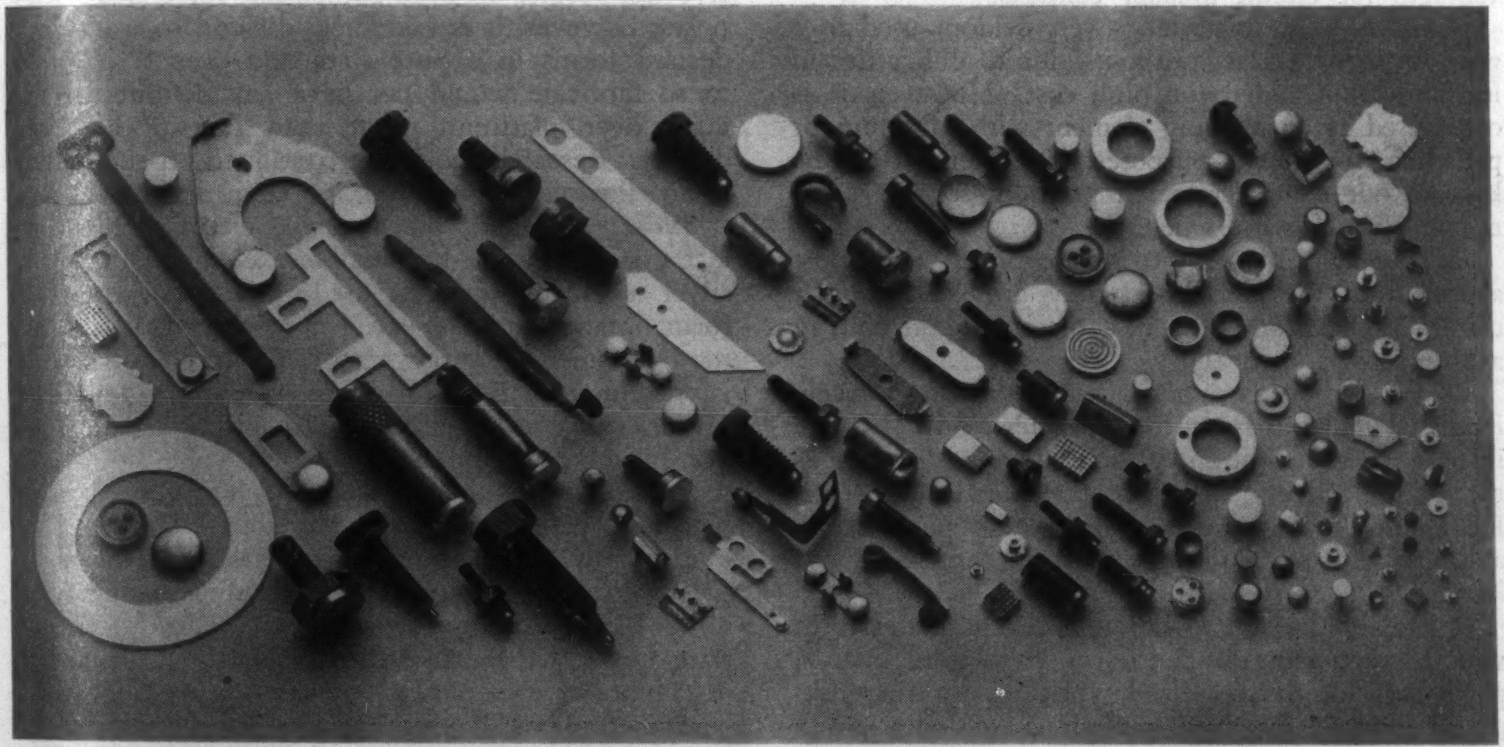
At present, indications are that the incorporation of copper in alloys or admixtures with silver, palladium, cadmium and cobalt is our main line of interest in copper. The incorporation of copper with graphite is also of interest.

*Gold:* Gold in itself is an excellent contact material, particularly when light pressures and low voltages are encountered, but not particularly applicable to high voltages or heavy current.

Alloyed or admixed with members of the platinum family, silver, nickel and the refractory metals, it covers a wide range of compositions adaptable to a widespread contact range. However, in our particular contact applications the only uses at the present time (due to restrictions on the material and its present high cost) are for certain types of telephonic, thermostatic and ultra-sensitive applications. It will not be necessary, therefore, for our contact research to cover gold or gold alloys in too great detail.

*Iridium:* This material is seldom used in a pure form for contact purposes. In a pure form, while extremely hard, it is also brittle and in addition, the cost is very high, due to its density and the scarcity of iridium sources. It is used effectively as an alloying element in combination with platinum and occasionally with osmium, palladium or rhodium for contact purposes. Iridium should be kept on our active list of contact materials for testing and development.

*Molybdenum:* Some forms of molybdenum have shown to advantage over tungsten in a limited number of services, apparently due to the fact that its oxides seem slightly lower in contact resistance than similar types of tungstic oxides, and its forte in pure form apparently is on low current high voltage applications. As a refractory metal in combination with silver, copper, nickel, and graphite, it has marked advantages from the standpoint of non-welding under overload conditions, and being somewhat harder mechanically than silver or copper parts to the same dimensions. It is incorporated as an active contact material in many powdered metal contacts and its advantages in these materials indicate that active research to broaden its applications is in order. It should continue to be one of our active contact research ele-



*A group of electrical contact assemblies made of various materials.*

ments. This same statement also applies to tungsten incorporated in powdered metals.

Also in the form of carbides of molybdenum and/or tungsten in conjunction with silver and/or copper, and/or nickel and/or graphite, a wide field of applications is open and deserves investigation.

*Nickel:* In itself, nickel in a pure form is occasionally used for contacts, particularly when exposed to fumes of hydrocarbon vapors, and under conditions where highly inductive loadings at low currents are to be controlled. As examples of this, nickel is occasionally used as a contacting medium in fuel pumps where the contacts are immersed in oil or gasoline, etc.

However, the main interest which we have in nickel is as an admixing and/or alloying element in conjunction with silver, copper, molybdenum and tungsten, and their carbides. At the present time nickel is an active ingredient in a number of powdered metals and sintered contacts. There are apparent indications from preliminary test results that admixtures of nickel with graphite in ratios as high as 70% Ni, 30% graphite may offer distinct advantages for circuit breaker contacts.

*Osmium:* This material is very seldom used in a pure form for contact purposes, due to difficulties in its fabrication and to its high cost. However, it is often used as an alloying element with platinum or palladium for contact purposes. This element can be kept in our contact research program for the same reason given for iridium.

*Palladium:* This is the lowest priced and most abundant of the platinum family group of contact materials, and is an excellent contact material both in a pure form and in alloys.

Pure palladium is somewhat soft, and is effectively increased in hardness with some electrical resistance increase by the addition of such alloying elements as ruthenium, silver, nickel, copper, platinum, etc. Palladium alloyed with silver in various percentages, and also with silver-nickel and silver-copper is used in various relay contacts.

It has also proven to be an excellent material in various percentages for use on voltage regulators, particularly of the polarized types, for certain types of thermostats, for driving contacts on light inductive loadings, such as on B eliminators, etc. Its contact usage should be actively pursued in our program, particularly with reference to its alloying with silver, copper, other members of the platinum group and with tungsten, molybdenum and their carbides.

*Platinum:* While one of the higher priced metals of the platinum family and too soft normally to use in a pure state for contact purposes, we have found its alloying with ruthenium, iridium and palladium to show marked advantages, also incorporation of platinum in various percentages with silver and copper increased the capacity of these lesser metals to a sufficient degree to enable these to be used for a number of "border line" applications. This metal, too, should be checked as an alloying or admixing agent with tungsten, molybdenum, their carbides, also with nickel for specific contact applications.

I currently have produced and tested (produced by sintering) compositions of 5 to 60 percent Pt, the remainder tungsten and ½% Ni without a great deal of advantage being shown for magneto contacts. I am presently testing a high percentage of platinum admixed with or alloyed with 5 to 18% W carbide for magneto contacts in place of the prevailing 25-50% iridium-platinum. Platinum-tungsten shows to advantage for voltage regulator contacts and spark plug electrode alloys. Definitely, tests should be continued on platinum, platinum alloy and admixture contacts.

*Rhodium:* This member of the platinum family is infrequently used alloyed with platinum as a contact material, but is not used in a pure form due to difficulty in its fabrication. The scarcity of rhodium and its high cost preclude its use for very many contact applications. However, it should not be omitted from our research at the present time.

*Ruthenium:* This member of the platinum family is mainly valuable to us for its hardening action when used with palladium or with platinum and in conjunction with silver. I do not have any conclusive test results on pure ruthenium for contact purposes; however, it is extremely difficult to work into desired forms in a pure state and even if possible to so fabricate would not have any definite advantages over platinum other than that of a lower density. Research should be continued on ruthenium as an alloying and/or admixing element for contacts.

*Silver:* Of all of the available elements for contact purposes, with the possible exception of copper, silver is the most widely used. Silver in the purest form obtainable is an excellent contact material, although somewhat soft where heavy mechanical wear is encountered. Both for this reason and to lower its initial cost, it is often admixed or alloyed with copper, nickel, cadmium, etc.

In addition to these materials when alloyed with platinum, palladium or other members of the platinum family, it takes on to a marked extent their superior contact characteristics and also increases somewhat in hardness. In addition to alloy forms and pure forms, we are at present using it in a number of composite forms. Our contact research should be developed primarily with two views in mind, namely,

(1) The development of other methods of assembling as an integral contact silver and silver alloys to desired backing by electro welding, by brazing and by mechanical or other desirable methods.

(2) The development of silver alloys, both lowered in price through base metal additions, such as copper, etc., and the development of superior types of high silver content alloys for thermostatic applications, special relay contacts to overcome freezing, etc.

It should also receive a considerable amount of further research as an alloying or admixing element with tungsten, molybdenum and their carbides.

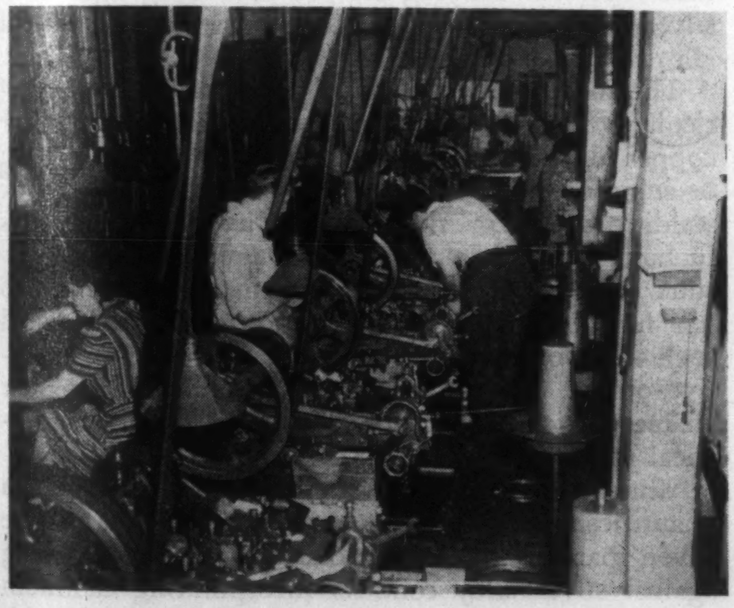
Silver is equal in importance to tungsten in our present necessary contact research and should rate an increasing amount of effort in the direction outlined above.

*Tungsten:* There is no need to outline here the many applications of tungsten contacts, or to try to bind them to any specific field. Since, at the present time, our test results indicate that both boron and silicon-doped tungsten are superior to other tungstens on normal ignition, etc. applications, research should be quickly extended along these lines.

## The Less-Used or Dependent Materials

*Antimony:* This material is a very poor conductor of heat and electricity, and, while used occasionally as an alloying element or admixture with copper and silver, it has no apparent advantages as a contact material. This same observation also applies to arsenic, which has occasionally been used in conjunction with copper or silver as a hardening agent; however, there have as yet been no outstanding examples of merit of either of these two materials as a contact alloying element.

*Beryllium:* This metal in itself as a commercially pure material does not show to advantage for contact purposes, since it readily oxidizes under arcing action and the oxide is extremely high in resistance. However, when alloyed with copper or silver it materially increases the hardness of both of these materials, and while also increasing their electrical resistance has some added advantages from the standpoint of non-freezing, lowered arcing and resistance to mechanical wear.



*Contacts are often formed by cold heading (cold upsetting) on such machines as these.*

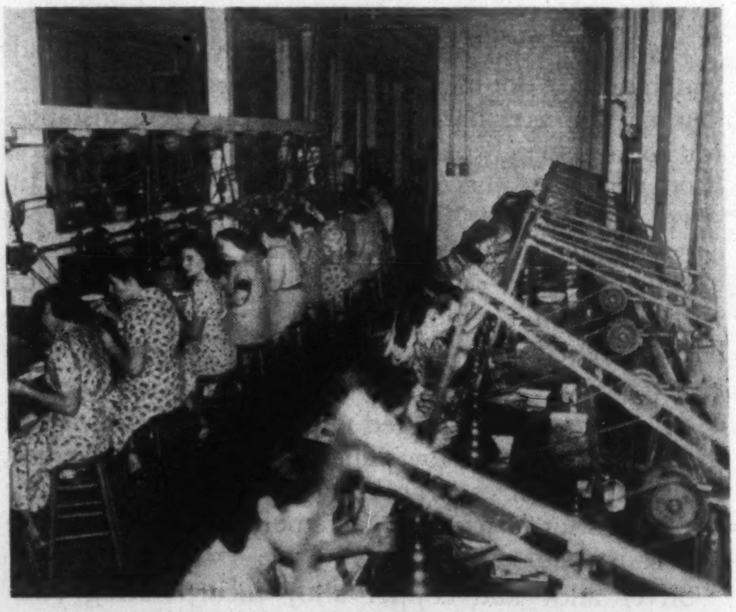
I have produced and tested silver and copper alloys having ½, 1, 2 and 3% by weight of beryllium, also silver-beryllium-molybdenum and silver-tungsten-beryllium. These materials, while showing an increased ability to resist welding (freezing) of the contacts, were higher in electrical resistance than equivalent materials of silver-molybdenum and silver-tungsten. They did show to some advantage for welding electrode tips, particularly for welding stainless steel, and where heavy mechanical wear was encountered.

Beryllium-doped tungsten and beryllium-doped molybdenum made by conventional methods were also tried, but did not show any apparent advantage, and the tests were accordingly dropped. Since at the present time beryllium does not show any outstanding advantages as a contact material, it has been temporarily eliminated from our contact research.

*Bismuth:* This material is a poor conductor of electricity, and its alloys usually expand on solidifying, causing some difficulty in its fabrication. Small amounts of bismuth added to silver and to copper were tried by the undersigned in compositions as high as 5% Bi, the remainder being copper or silver. At the present time, in our contact research, it is not being considered as a contacting medium.

*Boron:* I have no data on commercially pure boron, never having tested this material as an electrical contact. However, I have had prepared and tested alloys consisting of 80% Ag, 19% Cd, ½% Mg and ½% B, also alloys of ½% B and 99.5 Ag. Neither of these alloys checked to advantage on the particular applications on which they were tried, namely, relay contacts for horns and cut-outs.

In addition to this, the doping of tungsten with boron prior to its being worked into rod or sheet form, also for powdered metal admixtures, has apparently shown to advantage over some tungstens not so doped. Tungstens so produced, particularly in rod form, and contact discs cut from this rod, were very thoroughly tested with varying but encouraging results. Likewise, so-called "pill" contacts made from this boron-doped tungsten gave encouraging results, and silver-tungsten-boron, also copper-tungsten-boron showed up well both for electrical contacts, welding electrodes and mechanical wearing surfaces. Sheet, strip or ribbon tungsten contacts produced from this



*Radius grinding and polishing of contact assemblies assures a clean surface and correct contour.*

boron doping likewise showed some very interesting and encouraging results at normal operating temperatures, but to disadvantage at extremely low temperatures. Boron-doped tungsten has also shown to advantage for both spark plug electrodes and atomic hydrogen welding rod. Boron-doped molybdenum showed the same general trend as did boron-doped tungsten. In view of these results, research should be continued along the lines of boron as an alloying and/or admixing agent for contact purposes.

*Cadmium:* Pure cadmium has only shown to advantage as a contacting medium when plated on backings of silver or copper. Cadmium, however, has shown very definite advantages when admixed or alloyed with silver and/or copper, since it has definite arc quenching characteristics, particularly on a.c. services. It also hardens these materials, and adds a considerable amount of resistance to sulfiding or otherwise tarnishing of the silver or copper it is alloyed with. Cadmium oxide similarly used also showed superior properties.

At the present time we also incorporate cadmium in multi-element alloys, such as the boron-cadmium-magnesium-silver alloy referred to above.

This apparent cadmium contact improvement in silver and copper alloys, indicated silver-tungsten-cadmium, or silver-molybdenum-cadmium alloy or admixture would be advantageous. This admixture was tried out on large circuit breaker contacts on which there is a possibility of "freezing," with very favorable results. Cadmium is, therefore, placed on our "active" list as an alloying element to be thoroughly tested.

*Calcium:* This material primarily shows to advantage as a "doping" agent for tungsten and molybdenum, and as a hardening agent in a few instances for copper switch parts. I understand that tests have been run by others incorporating up to 1% Ca in silver, but the test results apparently were not very encouraging.

Calcium can, therefore, except for combination with tungsten or molybdenum at the present time be eliminated as an active element in our contact research.

*Chromium:* I have tested pure chromium and found that, while having a low inherent electrical resistance, it quickly oxidizes or otherwise changes its surface characteristics to have an extremely high surface contact resistance.

Silver alloy and copper alloy incorporating fractional percents of chromium as a hardening agent have shown to advantage. With reference to chromium-silver alloys, I tested several silver alloys containing small amounts of chromium, from 0.05 to as high as 1%. The material showed a decided increase in hardness, particularly after having been cold headed and a slight increase in resistance to sticking or freezing under overload as compared to fine silver. However, the advantage was not sufficient enough to continue research along these lines. No definite information regarding its possible effects as a possible doping agent on tungsten for contact purposes is as yet available for publication. Chromium has, however, shown to advantage in heat treatable copper alloys and/or admixtures thereof and merits further research.

*Cobalt:* Like chromium, cobalt hardens both silver and copper alloys, and in addition, it seems to have a slight snuffing action to help quench arcs. However, the difficulty of uniformly incorporating it in silver or copper alloys has led to its normal replacement with nickel. Parts cold headed from these alloys show marked increase in hardness over those not containing cobalt.

Cobalt is important to us as a bonding agent in the use of carbides for contact purposes. Pure cobalt (as pure as I was able to obtain from commercial sources) did not show to advantage as a contact material, having some of the same essentials of failure as chromium.. There is sufficient evidence of its improvement of silver and copper alloys to merit its being kept on our active list of contact elements.

*Columbium:* I have no personal test information regarding the actual testing of columbium in an essentially pure form as a contact material, but have been told by Dr. Balke of Fansteel Metallurgical Corp. that the test results there on it were extremely negative. It is possible that its use as a contacting medium in a vacuum might prove advantageous, also that its incorporation in silver in small percentages might show to advantage. While testing of such combinations is not urgent, it is something which should be tested for future informational reasons.

*Germanium:* Germanium, indium, lithium, magnesium and manganese, in the above list of contact elements, can all be grouped in one category, namely, their effect as alloying and/or hardening agents on silver and copper, also possibly on precious metal alloys.

The incorporation of small percentages of, in particular germanium, indium and lithium in silver or copper alloys, has resulted in resistance to tarnishing or sulfiding, some increased resistance to sticking or welding under overload conditions, slight increases in hardness, and in arc snuffing properties. Test results on the use of magnesium in quantities up to 3% have been reported and we ourselves have tested such alloys on relays, etc. Our test results were negative on d.c. circuits, indicating an enhanced transfer characteristic, and considerably higher inherent electrical resistance.

With reference to manganese, this has been used in quantities up to as high as 15% Mn, the balance silver, particularly as a polarized contact working against silver alloy contacts incorporating cadmium or palladium on the opposite side of the circuit with fair success. It did not show up, however, quite as well as coin silver (10% Cu—90% Ag) or cadmium-silver of either 10 or 15% Cd, remainder silver under overload circuit conditions, and did not compare too favorably with our 85% Ag—15% Ni on overload sticking tests, or under test as voltage regulator contacts or relay contacts.

It is believed that of the above materials, germanium, indium and manganese offer the greatest promise as active and effective alloying elements.

*Iron:* This metal is very seldom used as a contacting medium, even in an essentially pure form. It is occasionally used in circuit breakers, etc., where the parts can be made sufficiently large in bulk to overcome any resistance characteristics, etc., and even in these applications is normally silver or copper plated. However, iron as an alloying and admixing element has shown very favorably when used in a pure form in conjunction with silver or copper. Tests have also indicated that the addition of fractional percentages of iron to tungsten or molybdenum have increased the efficiency of these materials for contact purposes. In view of the favorable results obtained to date in conjunction with iron-silver, it is believed that we should continue our tests along this line actively with iron percentages from 5 to 50% combined with silver or copper, also with tungsten or molybdenum, incorporating iron and silver or copper into powdered metal type contact materials. Definitely, iron should be included in all contact research programs.

*Lead:* In itself lead is an extremely poor contact material, since it not only tends to oxidize readily but also has a fairly high electrical resistance. However, the incorporation of lead oxide and lead itself in small percentages in silver or copper gives an increased ability to withstand freezing under overloads and influences the hardness to a slight degree. I personally have tested lead-silver combinations from ½% Pb to as high as 10% Pb without obtaining favorable action, although I have never thoroughly tested lead oxide-silver or copper. The lead oxide-silver and/or copper is reportedly used actively by both General Electric and Westinghouse on certain types of circuit breaker contacts.

I have tested an experimental type of admixture made with 2% Pb, 58% Ag and 40% Mo by weight percent; however, this admixture did not show discernible advantages over 60% Ag—40% Mo. Under these circumstances it is believed that lead can be dropped at the present time from our active contact investigation.

*Mercury:* Some types of silver and copper amalgams have been tested for contact purposes with rather varied reports as to the test results obtained. They have shown to advantage principally on inductive circuits. Silver contacts filmed or coated with mercury have also shown encouraging results on certain circuits.

Mercury enclosed in a glass or metal container and in substantially pure form is widely used in various types of circuit breakers and pressure control switches. It is a contact element which merits a high place in our contact research program.

*Rhenium:* From personal experience with this material, it is very similar in characteristics to tungsten and molybdenum and apparently an intermediate material between these two in a pure form on contact applications. Several contacts of pure rhenium (worked in rod form and cut in disks) were tested and indicated a superiority to tungsten or molybdenum from a transfer standpoint, but with an increased tendency to oxidize. Its high initial cost and the small amount available would normally rule it out as a contacting material unless used as an alloying or admixing medium with tungsten, molybdenum or in a carbide form.

Apparently, from this standpoint, it can at the present time be omitted from a testing program, but should be further tested when time will allow.

*Silicon:* Under this can also be classed thorium, titanium, vanadium and zirconium. These materials are of interest from a contact standpoint only in their admixing or alloying action, particularly with reference to their age hardening characteristics on silver, copper and in the case of tungsten and molybdenum as doping elements.

Tests in various laboratories as well as our own tests have indicated the superiority of some tungstens doped with silicon as compared to calcium, etc., doped tungsten, particularly with reference to horn contacts, electric razor contacts and certain types of ignition applications.

*Tantalum:* I am conversant with very little actual information regarding the testing of pure tantalum for contact purposes, either in air or a vacuum. However, whatever information I have been able to obtain indicates that it is definitely of no value in its pure form. We have at the present time an alloy or admixture of 5% Ta—95% Ag which is being tested for relay and voltage regulator contacts.

This small percentage of tantalum offers a number of interesting possibilities, particularly with regard to contact surface contamination, etc., and will be reported on just as soon as test results are obtained. Pending these test results, I believe that tantalum can be dropped from the active testing list until a later date when this information may be of value in other lines.

*Tin:* This metal in a pure form is not a good contact medium, since it oxidizes readily under arcing action. I have tested alloys or admixtures incorporating up to 10% Sn, the remainder silver, also the same admixture with small additions of copper, and did not obtain any satisfactory test results. However, I do not believe that it will have to be considered in appraisals of various contact materials. It is occasionally used in the form of bronze, mainly for large size contactors.

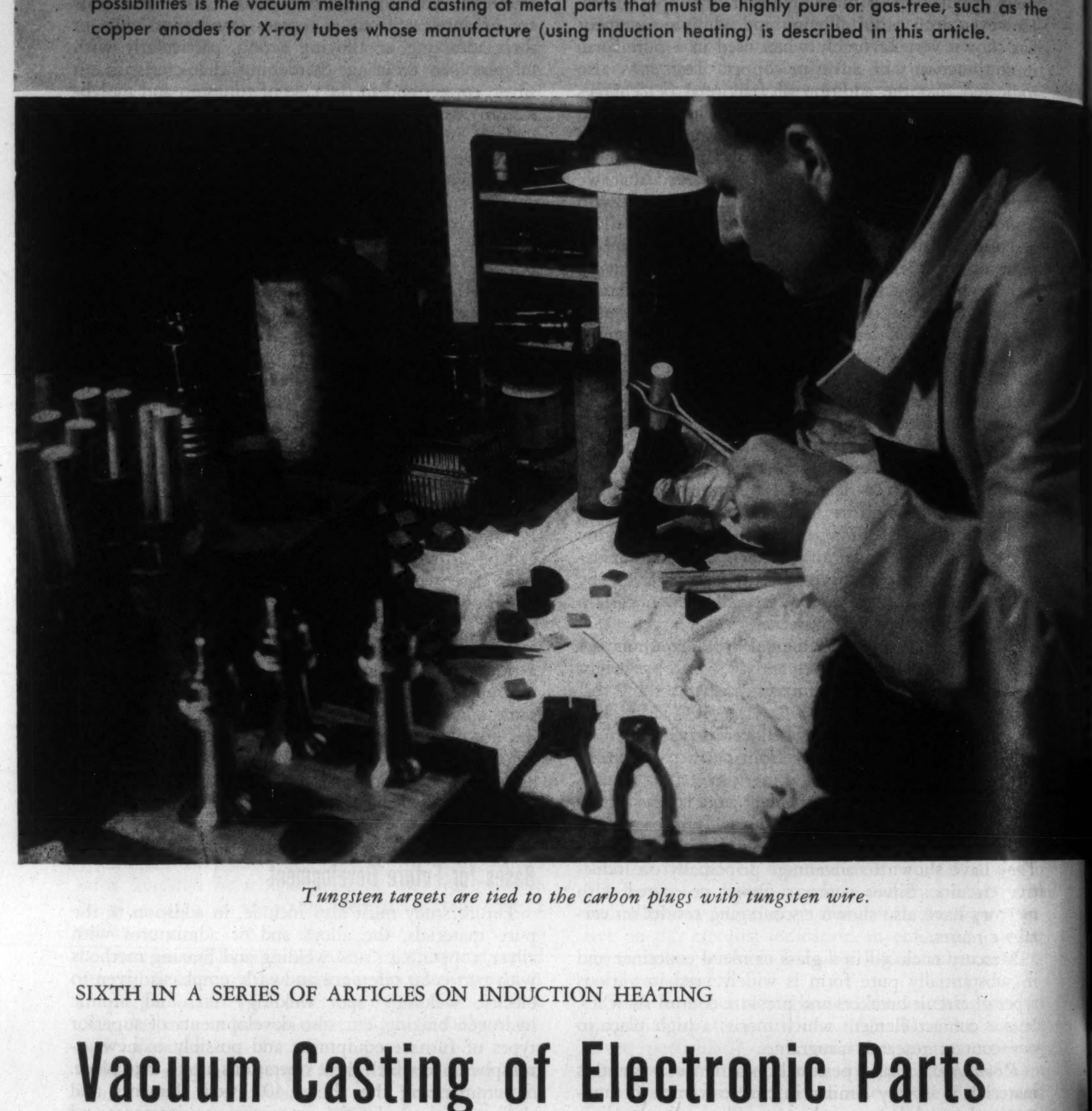
## Bases for Future Development

Future study must also include, in addition to the pure materials, the alloys and/or admixtures with silver, copper, etc., new welding and brazing methods with particular reference and early emphasis given to electric welding (spot welding) etc. and atomic hydrogen brazing, etc., also developments of superior types of furnace equipment and possibly to new atmospheres in which these operations are to take place.

Summarizing the above 40 listed elements and their possible application to contact requirements and the necessity for contact research on them, the list for early contact tests and applications in laboratory and field programs can be narrowed to the following names in order of their importance:

1. Tungsten in all forms.
2. Silver in all forms.
3. Platinum groups.
4. Molybdenum (named in 4th rank since it has not as yet definitely established itself in a number of fields).
5. Carbon impregnated materials.
6. Copper alloys and admixtures.

**A Methods Article** Vacuum and low-pressures will be much more widely used in the metal-working industries after the war than they were prewar. One of the most interesting applications with broadly useful possibilities is the vacuum melting and casting of metal parts that must be highly pure or gas-free, such as the copper anodes for X-ray tubes whose manufacture (using induction heating) is described in this article.



*Tungsten targets are tied to the carbon plugs with tungsten wire.*

### SIXTH IN A SERIES OF ARTICLES ON INDUCTION HEATING

# Vacuum Casting of Electronic Parts

### by KENNETH ROSE *Engineering Editor,* METALS AND ALLOYS

When COPPER is to be used as an electrical conductor, the absorption of gases by the molten metal poses a major refining problem. A grade of metal especially prepared, with precautions taken to reduce the oxygen content particularly, is offered as oxygen-free high conductivity copper.

Metals for use in vacuum tubes also require painstaking care in their preparation and fabrication to exclude gases. Any gases absorbed by the metals may later be liberated in the tube under service conditions, decreasing the vacuum and causing deterioration of the filament. To meet this problem a technique has been developed by Machlett Laboratories, Inc., Springdale, Conn., for casting copper parts for vacuum tubes, holding the metal in an extremely high vacuum during the entire process.

## The Parts and Setup

One of the parts so cast is the copper anode used in X-ray tubes. The procedures used are typical of those for the vacuum casting technique. The part requires that a tungsten insert be cast into the copper block, and that the anode have one side inclined at an angle of 20 deg. to the central axis of the anode. The insert becomes the target in the X-ray tube. Sizes are small, the parts ranging from 3-in. lengths and ⅞-in. diameters to about 5-in. lengths and 2⅝-in. diameters. The weight of the smallest anode will be less than ½ lb.—0.416 lb. exactly—the largest 3 lb.

For tubes that will utilize high energy, internal water or oil cooling of the anode is required in addition to the usual convection cooling. A second insert is then required consisting of a specially made coil of alloy steel tubing, placed over the target in the mold. Molds used are of graphite, with the mold cavity machined to size and shape. The mold serves as a graphite crucible, with the copper ingot so positioned that, when molten, it will run down into the mold. Melting is accomplished by induction heating.

In preparation for casting the anodes, the tungsten targets are mounted on cylindrical carbon plugs, machined at one end to the desired angle. Tungsten wires hold the targets in position. The plugs fit snugly into the bottoms of the graphite crucible-molds, the anodes being cast in inverted position. A small ingot of deoxidized copper, exactly desired weight, is placed in the mold above plug and target.

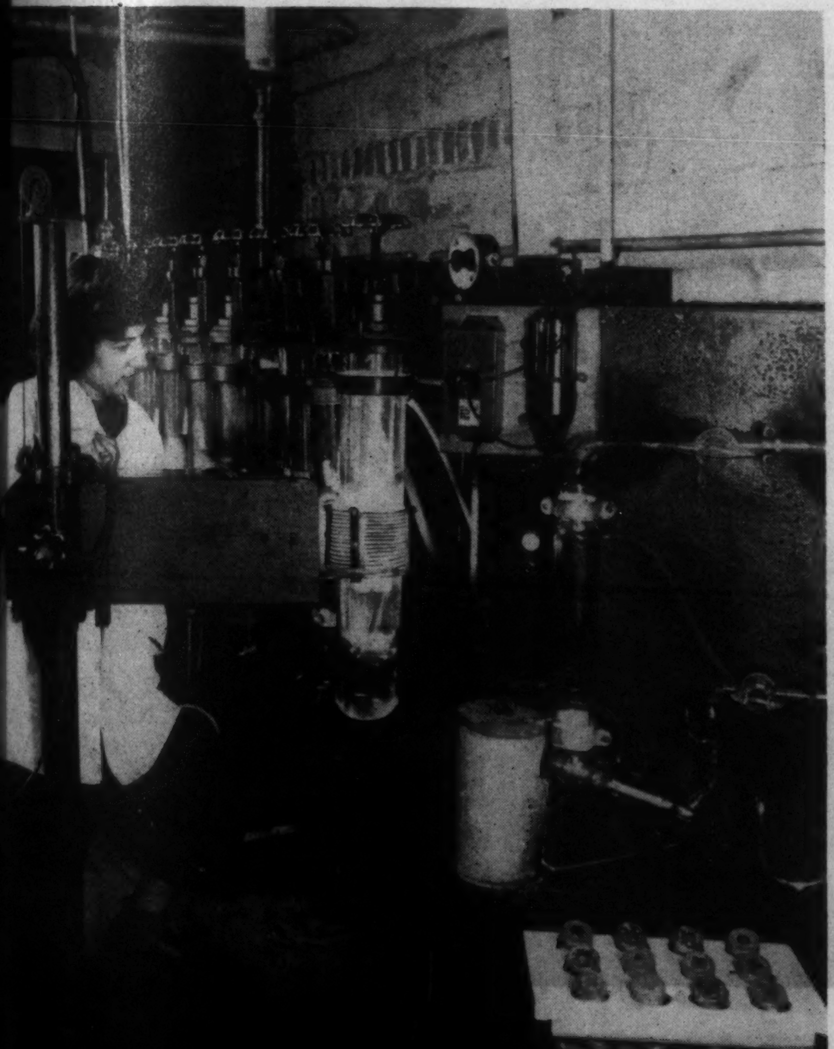
## Melting Equipment and Process

The furnace for the vacuum casting operation is of glass, and consists of two cylinders, with cooling water circulating between them. An inner cylinder of quartz serves to retain heat, while the outer glass sleeve acts as a water jacket. The graphite crucible-mold, with its charge of copper, is suspended inside the furnace, and air is evacuated by means of oil diffusion pumps. A vacuum corresponding to a pressure of 0.00001 mm. of mercury is developed and maintained during the casting process.

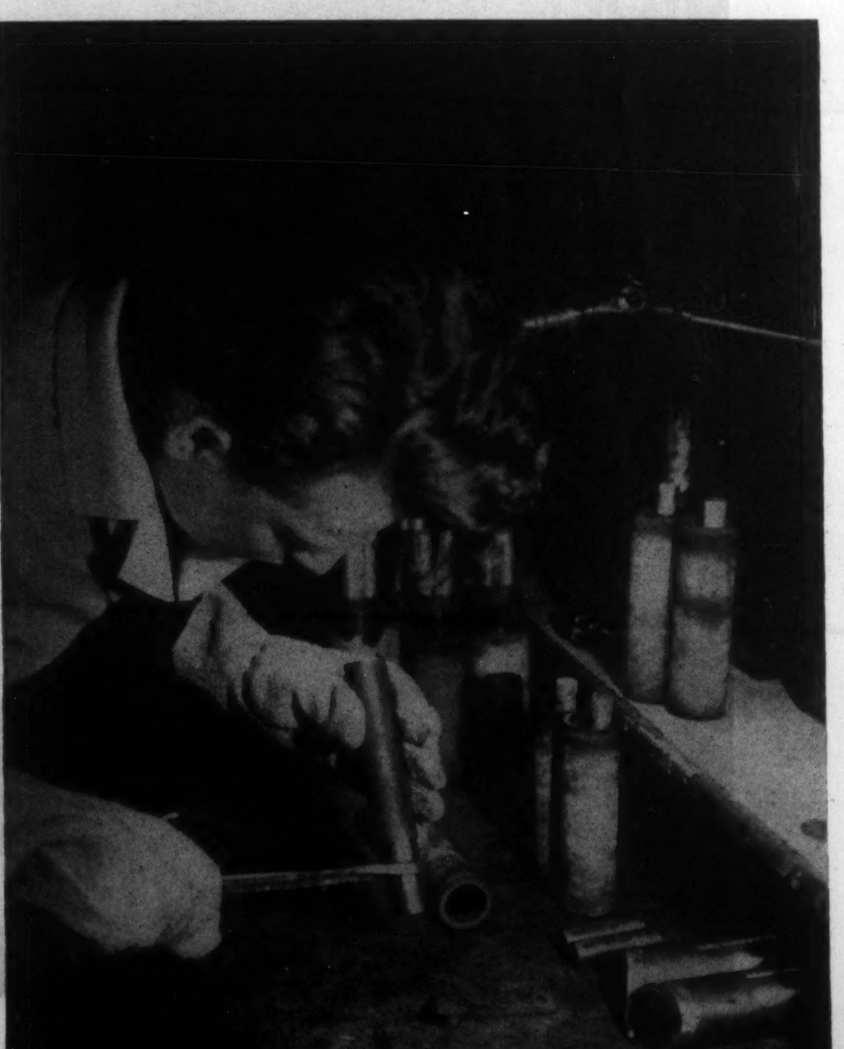
Melting is accomplished by high frequency induction heating, in this way eliminating any need for breaking the vacuum. A coil is placed around the glass furnace in a position corresponding to the location of the copper ingot. Energy is applied for from seven to ten minutes at frequencies of from 150 to 250 kilocycles. An electronic-type oscillator is used, and input ranges from 7 kilowatts to 25 kilowatts, depending upon the type of casting required. The molten copper settles into the lower part of the mold, over and about the tungsten target and the cooling coil insert, if used.

The vacuum is maintained during the cooling period, requiring approximately 10 minutes additional. The induction coil is so adjusted as to give proper conditions for desired crystal formation during this part of the cycle. The gases freed during the melting are removed by the vacuum pumps, so that there is no reabsorption during the cooling period.

*Heating coil in place, the copper ingot is fused inside the glass furnace.*

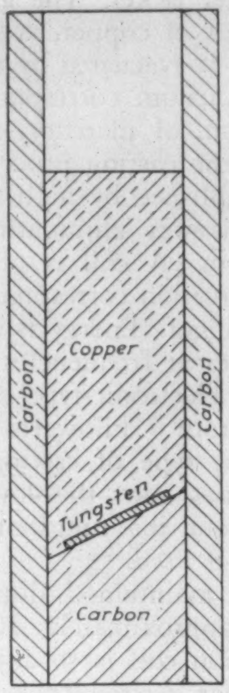


*The cast anodes are removed from the graphite molds. Cooling coils may be cast into the anodes for heavy tube service.*



Formation of oxides is also prevented by the gas-free environment.

When the casting has cooled sufficiently to permit handling, and to preclude any possibility of absorption of gases, the vacuum is broken and the graphite mold removed from the furnace. The anode casting is withdrawn from the graphite cylinder without breaking the cylinder itself. A pair of tongs fitting the casting aid in removing the part and reduce danger of cylinder breakage. The cylinders can be re-used until they give evidence of damage.



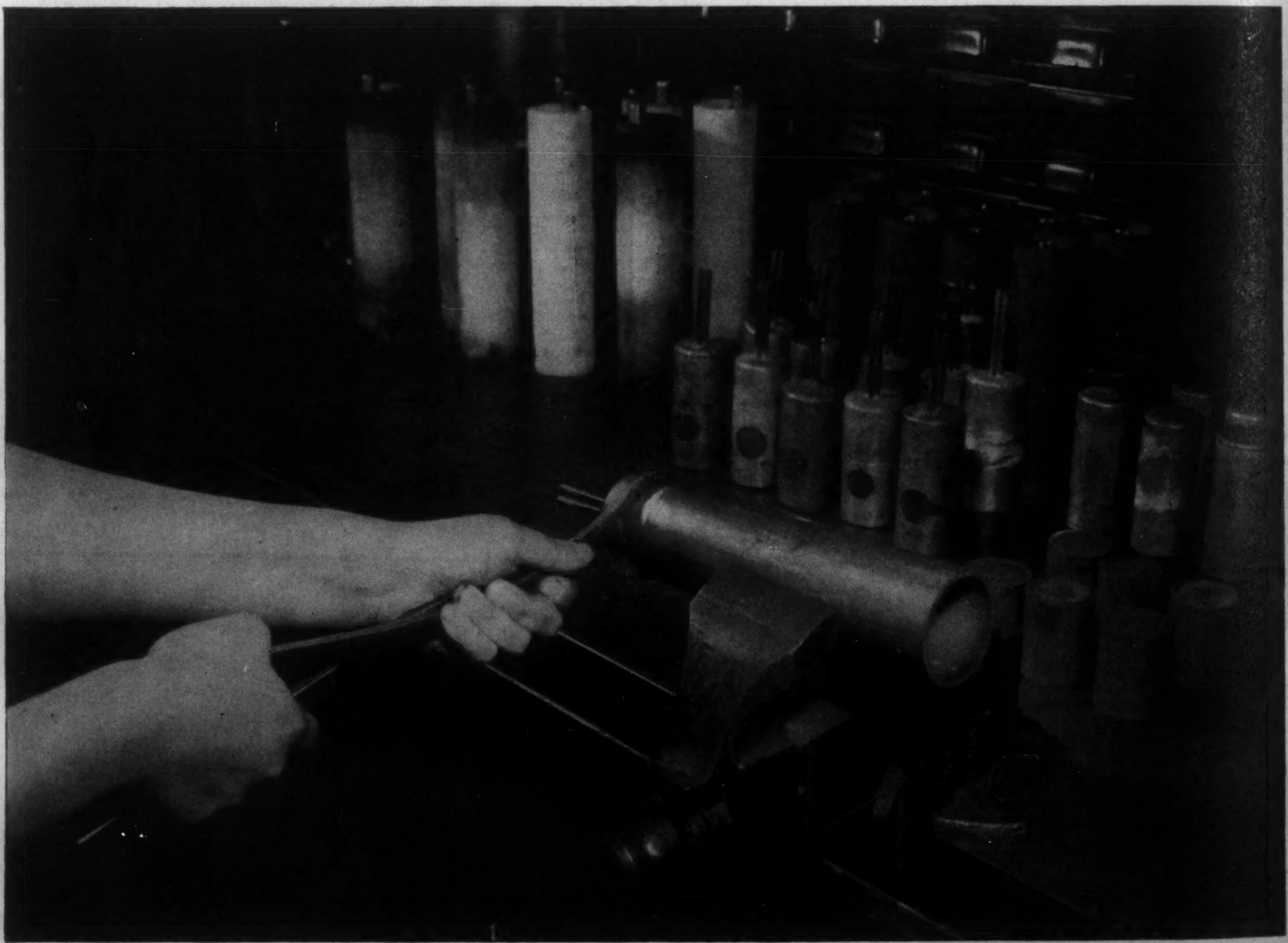
*The arrangement of the crucible-mold, graphite plug, tungsten target, and copper casting is shown.*

In order to obtain good production with this small installation, a series of eight furnaces is arranged so that the heating coil may be applied to them successively. The process can then be made continuous, producing a casting about every 25 min.

Since there is no surface corrosion of the part when cast in absence of air, and the graphite of the molds does not adhere to the metal, there is no loss of metal from the surface of the casting. Dimensions can be held to very close tolerances—to about 0.0001 in.

The technique described for vacuum casting of copper can be used for most metals. The metal should be fusible at temperatures within the reach of induction heating apparatus of a size usable with the glass furnaces described. Size limitations for the item to be cast are set by the size of the furnace, and by the rapid loss of efficiency as coupling between the ingot and the induction coil is decreased. Size of the furnace wall, including the water jacket, and the space inside the furnace make impossible any close coupling, such as would be customary for heat treatment of steel objects by induction heating.

*Cooling coils may be cast into the anodes for heavy tube service.*



**A Materials Article** Often considered among the lowliest of materials in their resistance to sea-air corrosion, magnesium alloys are shown by cooperative coastal exposure tests described here to be surprisingly resistant, and in some cases to be actually among the best of the materials tested. The data on the relative merits in this respect of several magnesium alloys, aluminum alloys, mild steel and galvanized iron presented here will not only aid materials engineers in their selections but will certainly serve as well to correct some prevalent impressions of the relative corrodibility of magnesium alloys.

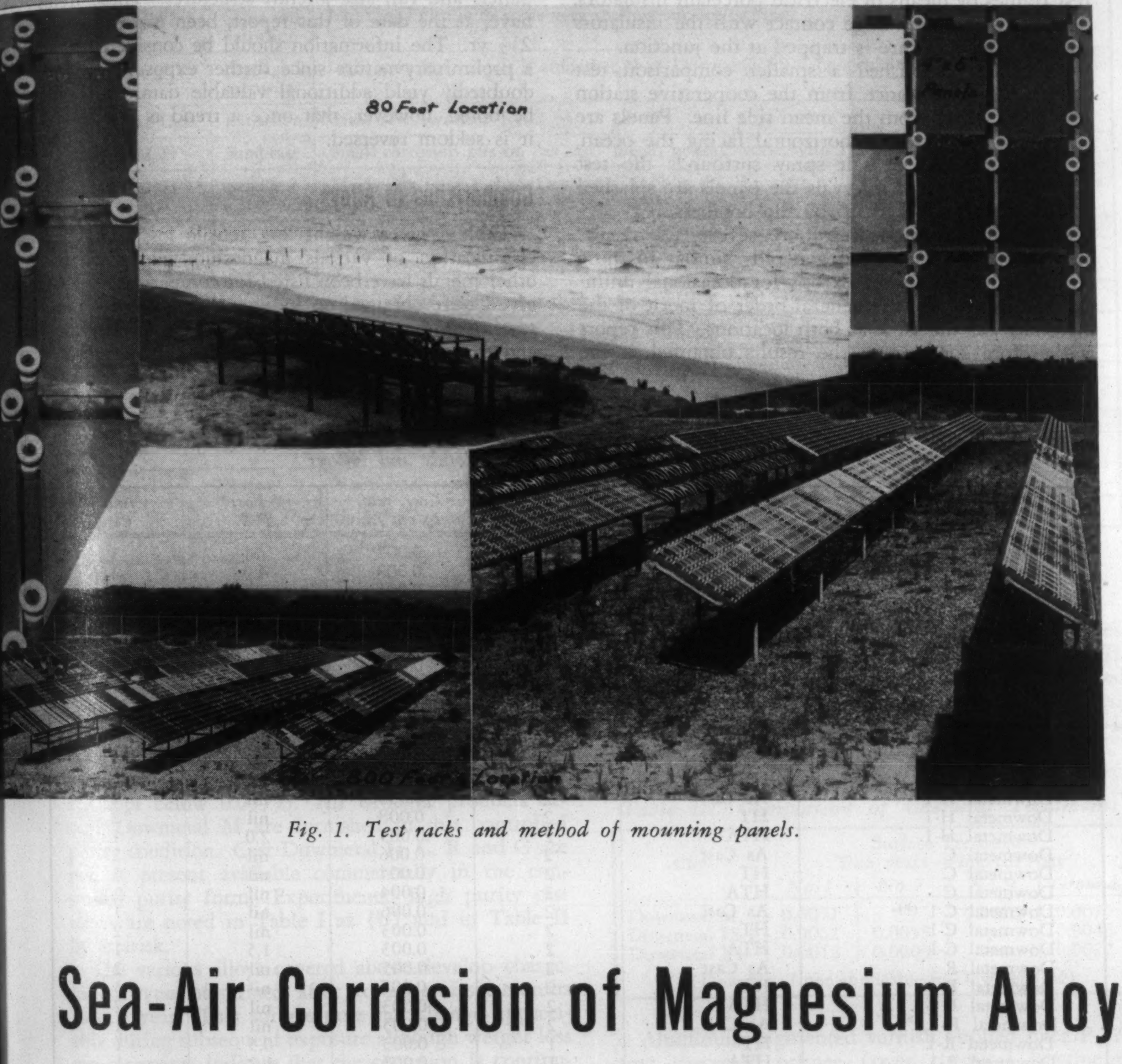


*Fig. 1. Test racks and method of mounting panels.*

# Sea-Air Corrosion of Magnesium Alloys

by **J. A. PELOUBET** *Magnesium Division, The Dow Chemical Co., Midland, Mich.*

On the shore of the Atlantic Ocean in North Carolina, The Dow Chemical Co. has established a testing station for the seacoast exposure of magnesium alloys. This station was set up in cooperation with the International Nickel Co., Inc., and the Carnegie-Illinois Steel Corp.

The combined tests of the three companies have resulted in an extensive display of the resistance to a salt atmosphere of steel, nickel, and magnesium alloys. The test location has developed to the extent that it has been termed a standard for the atmospheric exposure of metals. More than 15,000 individual specimens have been exposed to date by Dow and the cooperating companies.

Racks have been set up 800 ft. from the mean tide line with specimens inclined 30 deg. to the horizontal, facing south. The racks are far enough from the ocean that no measurable differences exist from one spot to another but are still well within the range of the salt atmosphere that prevails close to the shore. Specimens of standardized size, 3 in. x 6 in., 4 in. x 6 in., or multiple thereof, are held on the test frames by means of electrical porcelain insulators. Specimens maintain edge contact with the insulators such that no moisture is trapped at the junction.

Dow has established a smaller comparison test station a short distance from the cooperative station at a point 80 ft. from the mean tide line. Panels are exposed 45 deg. to the horizontal facing the ocean. A continual mist of salt spray surrounds the test rack and at frequent intervals the panels are splashed with salt water kicked up by the breakers.

Although corrosion was more severe, the results at this location have been generally similar to those at the 800-ft. location. Except for occasional unimportant exceptions, the general order of merit of the materials was the same at both locations. This report is therefore confined to the results obtained at the 800-ft. location.

Fig. 1 shows the test racks and the method of mounting panels. (As a general guide to the severity of the test location, it should be noted that steel structures in the vicinity must be repainted at least every one or two years.)

The data contained in this summary are based upon tests of standard panels, riveted or welded panels and full size aircraft structures. These items have, at the date of this report, been exposed up to 2½ yr. The information should be considered as of a preliminary nature since further exposure will undoubtedly yield additional valuable data. It should be noted, however, that once a trend is established, it is seldom reversed.

## Comparisons of Alloys

Table I gives weight loss, tensile loss and visual classification of various magnesium alloys. A few other metals have been listed for comparison. Values given were obtained on individual test panels, representing neither maximum nor minimum results. Sheet and extrusion specimens have ground surfaces; castings are machined. The specimens are not protected by chemical treatment or paint schedules. Clad 24ST,

*Table I. Comparison of Various Metals and Alloys*

| *Alloy* | *Form* | *Years on test* | *Corr. rate, mg/cm²/day* | *% Loss* T. S.* | *Visual** Class* |
|---|---|---|---|---|---|
| Dowmetal M | Extrusion | 2 | 0.007 | nil | 3 |
| Dowmetal J-1 | Extrusion | 2 | 0.003 | 4.0 | 1 |
| Dowmetal O-1 | Extrusion | 2 | 0.002 | 3.3 | 1 |
| Dowmetal Z-1 (a) | Extrusion | 1 | 0.037 | 10.0 | 5 |
| Dowmetal Mh | Sheet | 2 | 0.008 | 10.3 | 3 |
| Dowmetal Ma | Sheet | 2 | 0.009 | 4.5 | 3 |
| Dowmetal FS-1h | Sheet | 2 | 0.005 | 6.0 | 2 |
| Dowmetal J-1h | Sheet | 2 | 0.003 | 7.1 | 1 |
| Dowmetal J-1a | Sheet | 2 | 0.003 | 2.2 | 1 |
| Dowmetal M | As Cast | 2 | 0.009 | nil | 4 |
| Dowmetal H | As Cast | 2 | 0.007 | 1.4 | 2 |
| Dowmetal H | HT | 2 | 0.006 | nil | 3 |
| Dowmetal H | HTA | 2 | 0.005 | 0.5 | 2 |
| Dowmetal H-1 (b) | As Cast | 2 | 0.008 | nil | 1 |
| Dowmetal H-1 | HT | 2 | 0.008 | nil | 2 |
| Dowmetal H-1 | HTA | 2 | 0.005 | 2.0 | 1 |
| Dowmetal C | As Cast | 2 | 0.006 | nil | 2 |
| Dowmetal C | HT | 2 | 0.004 | nil | 3 |
| Dowmetal C | HTA | 2 | 0.004 | nil | 2 |
| Dowmetal C-1 (b) | As Cast | 2 | 0.006 | nil | 1 |
| Dowmetal C-1 | HT | 2 | 0.003 | nil | 2 |
| Dowmetal C-1 | HTA | 2 | 0.003 | 1.5 | 1 |
| Dowmetal R | As Cast | 2 | 0.005 | nil | 2 |
| Dowmetal R | HT | 2 | 0.003 | nil | 3 |
| Dowmetal R | HTA | 2 | 0.003 | nil | 2 |
| Dowmetal R-1 (b) | As Cast | 2 | 0.005 | nil | 1 |
| Dowmetal R-1 | HT | 1 | 0.003 | 0.5 | 1 |
| Dowmetal R-1 | HTA | 1 | 0.003 | 1.2 | 1 |
| Dowmetal G-1 (b) | As Cast | 2 | 0.006 | nil | 1 |
| Dowmetal G-1 | HT | 2 | 0.003 | 1.5 | 1 |
| Dowmetal G-1 | HTA | 2 | 0.002 | 1.0 | 1 |
| Dowmetal R-1 | Die Cast | 2 | 0.002 | nil | 1 |
| 3S, Aluminum | Sheet | 2 | nil | nil | 2 |
| 17ST, Aluminum | Sheet | 2 | nil | 0.1 | 3 |
| Clad 24ST, Aluminum | Sheet | 2 | 0.0003 | 0.2 | 1 |
| Mild Steel | Plate (⅛ in.) | 1 | 0.460 | 31.5 | 6 |
| Galvanized Iron | Sheet | 2 | 0.006 | 1.8 | 4 |

* Values are based on 3 or 4 test bars. Experience indicates that larger numbers of bars are necessary for accurate results.

** 1 = best, scale not linear.

(a) Experimental material illustrating the possibility of high corrosion rates through random addition of metals to the alloy.

(b) See paragraphs on Comparison of Alloys.

*Table II. Surface Condition After Exposure*

| *Alloy* | *Form* | *Condition* |
|---|---|---|
| Dowmetal M | Sheet and extrusion | Dark gray film dotted with small round spots of white corrosion product, removal of which reveals small pits. |
| Dowmetal FS-1 | Sheet and extrusion | Light gray film with some very shallow surface etching. |
| Dowmetal J-1 | Sheet and extrusion | Light gray film which is smoother than Dowmetal FS-1 (no etching). No visible attack. |
| Dowmetal O-1 | Extrusion | Same as Dowmetal J-1. |
| Dowmetal H | Sand cast | Small corrosion pits on "as cast" metal, getting worse with HT and better again on HTA. |
| Dowmetal H-1* | Sand cast | Much less pitting than Dowmetal H, but the HT state still shows more attack than "as cast" or HTA. |
| Dowmetal R-1 | Die cast | One of the most corrosion resistant magnesium alloys. Light gray film but no visible attack. |
| Dowmetal R-1* | Sand cast | Very smooth surface which is dull but does not show any corrosion product or pitting. |
| Dowmetal G-1* | Sand cast | Ditto. Same or smoother than Dowmetal R-1 sand cast. |
| 3S | Sheet | Similar to Dowmetal J-1 but has a slight etch. |
| 17ST | Sheet | Etching which is worse than any of the -1 magnesium alloys. Visible corrosion product. |
| Clad 24ST | Sheet | Brighter than magnesium alloys. |
| Galv. iron | Sheet | Shows more corrosion product on the zinc surface than any of the above magnesium alloys. Slight rusting of edges. |
| Mild steel | Plate | Rusts badly and scales. |
| Copper | Sheet | Splotchy brown or green film formation. |

* See paragraphs on Comparison of Alloys.

mild steel and galvanized iron were exposed "as received." The visual classification represents the order of corrosion—No. 1 best—and is not linear in nature.

The designation "-1" after an alloy type indicates that the alloy was made up to contain only controlled amounts of impurities for the purpose of increasing corrosion resistance. Iron and nickel in particular are kept below 0.005%. All wrought products except Dowmetal M are furnished in this controlled purity condition. Cast Dowmetal H, C, R and G are not at present available commercially in the controlled purity form. Experimental high purity cast alloys are noted in Table I as (b) and in Table II by asterisk.

The various alloys covered above develop characteristic types of surfaces after exposure of six months to one year. This surface does not change appreciably during subsequent exposure although weight loss measurements indicate that the corrosion is continuing normally. Table II shows the typical surfaces resulting from coastal exposure. The original surface condition is the same as shown above.

## Chemical Treatments and Paints

Based on 2½ yrs. exposure of unpainted panels, the Dow No. 7 dichromate treatment appears to protect Dowmetal FS-1 and J-1 somewhat better than Dow No. 1 (Chrome-Pickle). Likewise Dow No. 9 (galvanic-anodize) is visibly better than Dow No. 1 on M alloy although all of these treatments show some protective value in contrast to the light corrosion (dulling) of the bare magnesium surfaces. Weight loss comparisons are shown in Table III. While ground panels do not appear to have corroded much more than those that were chemically treated, it should be remembered that the chemical finish is essential for satisfactory paint adhesion.

*Table III. Comparison of Chemical Treatments*

| *Alloy* | Surface Treatment Two years — mg/cm²/day | | | |
|---|---|---|---|---|
| | *No. 1* | *No. 7* | *No. 9* | *Ground* |
| Dowmetal M | 0.0071 | — | 0.0075 | 0.0075 |
| Dowmetal FS-1 | 0.0062 | 0.0053 | — | 0.0048 |
| Dowmetal J-1 | 0.0018 | 0.0009 | — | 0.0027 |

(Dow No. 7 not applicable to Dowmetal M)

Aluminum pigmented varnish applied over P-27b zinc chromate primer (over chemical treatment) stands up much better than either lacquers or enamels. No failures have been found at either test location on panels protected by aluminum varnish. Camouflage finishes chalk rapidly and have little or no protective value.

## Contact Corrosion

*Rivets:* One and a half years exposure of Dowmetal J-1h (Chrome-Pickle) set with 56S, 2S and A17ST rivets shows no galvanic-corrosion around the 56S and definite attack with rings of corrosion product

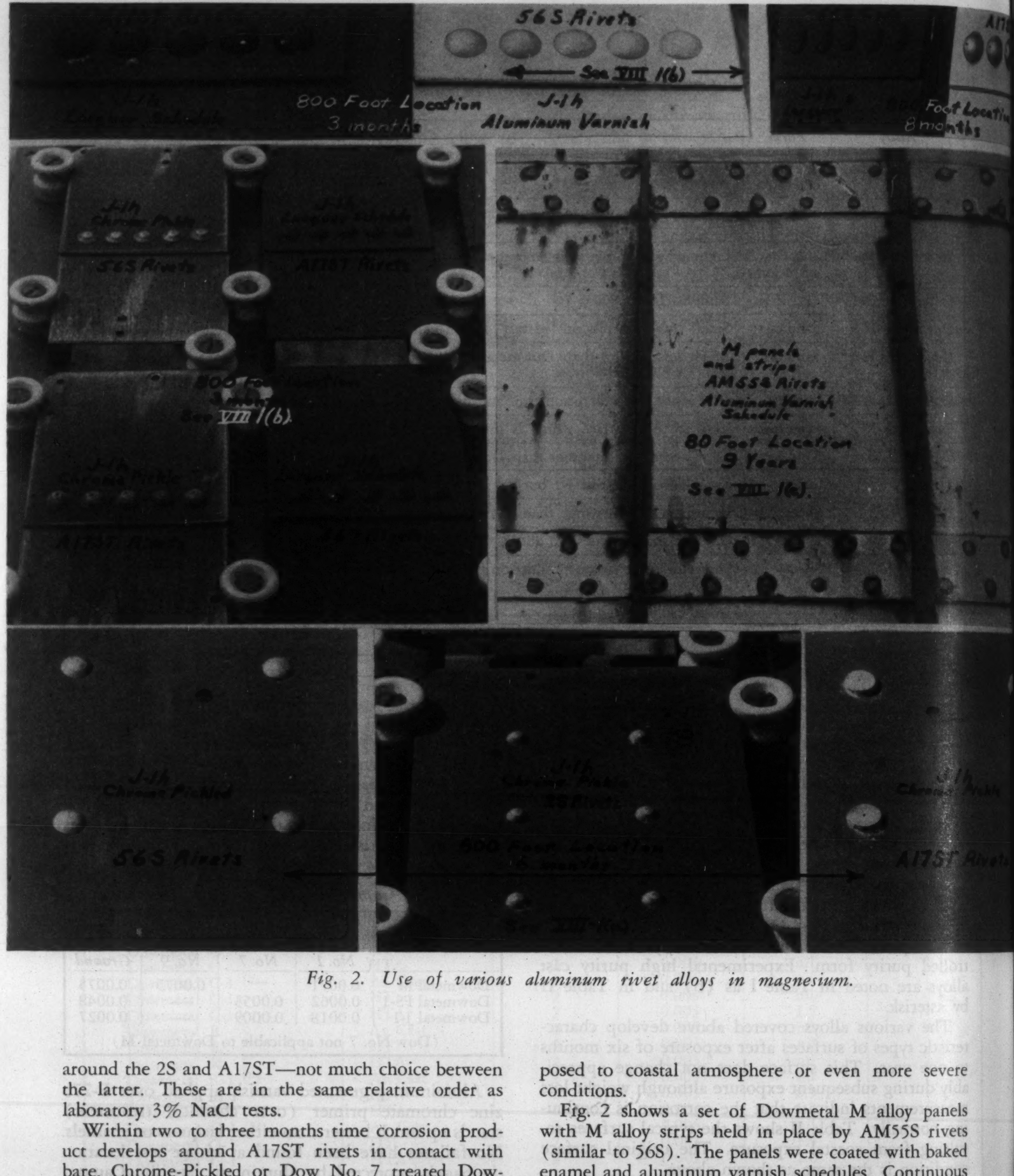

56S Rivets
See VIII 1(b)
800 Foot Location
3 months
J-1h
Aluminum Varnish
Foot Location
8 months
J-1h
Chrome Pickle
56S Rivets
A17ST Rivets
800 Foot Location
See VIII 1(b).
J-1h
Chrome Pickle
M panels
and strips
AM55S Rivets
Aluminum Varnish
Schedule
80 Foot Location
9 Years
See VIII 1(a).
J-1h
Chrome Pickled
56S Rivets
J-1h
Chrome Pickle
800 Foot Location
J-1h
Chrome Pickle
A17ST Rivets

*Fig. 2. Use of various aluminum rivet alloys in magnesium.*

around the 2S and A17ST—not much choice between the latter. These are in the same relative order as laboratory 3% NaCl tests.

Within two to three months time corrosion product develops around A17ST rivets in contact with bare, Chrome-Pickled or Dow No. 7 treated Dowmetal J-1h—also, Dow No. 7 plus two coats of P-27 zinc chromate primer plus two coats L-51 pigmented lacquer. In eight months failure is noted around A17ST contacting J-1h coated with Dow No. 7 plus two coats of P-27 primer plus two coats V-10 varnish aluminum pigmented.

There has been no evidence of corrosion around any 56S rivet. This definitely shows the need of 56S rivets in magnesium structures, especially when exposed to coastal atmosphere or even more severe conditions.

Fig. 2 shows a set of Dowmetal M alloy panels with M alloy strips held in place by AM55S rivets (similar to 56S). The panels were coated with baked enamel and aluminum varnish schedules. Continuous exposure since 1935—9 yrs.—at 80 ft. from the ocean has only recently resulted in slight pitting around some of the rivets.

*Dissimilar Metal Assemblies:* Steel in direct contact with Dowmetal H alloy (cast in) for 1 yr. causes, through galvanic action, a narrow ring (1/16 in.) of corrosion product on the magnesium. The balance of H alloy is in the same condition as though exposed alone. The steel shows semi-protection in a

⅛ in. ring next to the magnesium, but the balance is rusted badly (Fig. 3).

In order to gain information on the worst possible condition of contact between magnesium and various dissimilar metals, a series of panels was made up in which bare Dowmetal J-1 was fastened directly to the other metals by means of cadmium plated steel screws. No sealers or other form of insulation were used. The dissimilar metal contacts included 3S, 17ST, 24ST, clad 24ST and 52S aluminum alloys, lead, mild steel, galvanized iron, zinc, copper, brass, Monel and 18-8 stainless.

At one year, although some galvanic attack was evident, all of the panels were in satisfactory condition for further test. In all cases the cadmium plated steel bolts caused some galvanic attack on the Dowmetal J-1, but this should be neglected in examining the effects of other metals. The extent of attack could best be seen by examining the edge of the J-1 where it contacted the other metal. Based on visual examination, the dissimilar metals can be placed in three groups according to degree of attack:

| | |
|---|---|
| Most galvanic attack | Copper, brass, Monel, 18-8, mild steel, 17ST |
| Intermediate | 3S, 24ST, clad 24ST, lead, galvanized iron, zinc |
| Least galvanic attack | 52S |

Since magnesium alloy assemblies are frequently attached to steel structures, it seemed to be of interest to investigate the resistance of such assemblies to a coastal atmosphere. As shown in Fig. 4, specimens were made up with the junctions of Dowmetal J-1:H:H:steel. Cadmium plated steel bolts were used. One specimen was left bare, one was painted and another painted panel included the use of Ethocel washers between the cadmium plated bolts and the magnesium.

In the case of the painted specimens, each panel received two coats of primer before assembly and the entire unit was given two coats of lacquer after assembly. Duplicate sets were exposed at the 800-ft. and 80-ft. locations.

*Table IV. Contact Corrosion of Bolted Panels*

| *Bolt Material* | *Dowmetal* | |
|---|---|---|
| | *M* | *J-1* |
| Steel | C | E |
| Cadmium plated steel | B | D |
| Zinc plated steel | B | C |
| Brass | B | E |
| Cadmium plated brass | B | E |
| Zinc plated brass | A | A |
| Cadmium plated steel + 3S washers | A | A |
| Cadmium plated steel + 17ST washers | A | A |
| Cadmium plated steel + 52S washers | A | A |
| Cadmium plated steel + Ethocel washers | A | A |
| Monel | C | E |

At six months, the bare assembly showed considerable rusting of the steel with slight galvanic corrosion of Dowmetal H panel which it contacted. Some attack developed around the cadmium plated steel bolts. (The cadmium plate failed on the under side of the specimen.) No corrosion of any kind was visible on either of the painted panels.

*Bolts:* Although many structures are built up using riveted or welded joints, it is sometimes necessary to use bolts. They may be used either in the assembly of a structure or for attaching the part to existing assemblies. A series of bare metal Dowmetal M and J-1 panels were prepared in which various types of bolts were inserted into drilled holes. The assemblies were exposed in duplicate at both test locations for a period of six months.

A comparison of the galvanic action caused by the various bolts is shown in Table IV. The letters show the order of attack, A being least, and should not be considered as having a quantitative meaning.

## Welds

*Tack Welds—Arc:* Tack welds in Dowmetal J-1h produced by arc welding set up very high residual stresses. Exposure of these welds unpainted but Chrome-Pickled results in cracking within five to six weeks. Paint (two coats P-27 primer plus two coats L-51 lacquer) retards this cracking so that cracks appear in about five months or more depending upon the degree of protection. Stress relief annealing of tack welds 1 hr. at 400 F has to date (2½ yrs. exposure) prevented cracking. These statements apply to test panels and fabricated structures.

*Seam Welds—Arc:* Seam welds in Dowmetal J-1 (butt) are also subject to this cracking but require approximately 1 yr. exposure before cracking takes

*Fig. 3. Steel inserts cast into magnesium.*

800 Foot Location
6 months
H
Steel

place on unpainted metal. Painting or stress relieving has thus far prevented the cracking.

*Seam Welds—Gas:* No cracks have been detected on unpainted gas welded Dowmetal M alloy. (2½ yrs.)

*Circle Welds—Arc:* Unpainted Dowmetal J-1h panels made up as circle welds (worst stressed condition) crack in a few weeks (Chrome-Pickle) unless stress relieved—in which case no cracks have shown up in two years.

*Spot Welds:* Spot welds made with Dowmetal Ma sheet have been exposed one year with only Chrome-Pickle protection. A small amount of corrosion product has developed on the spots where copper was deposited by the welding electrodes. When spot welds are cleaned free of the copper (on surface only), the corrosion resistance of the spot is the same

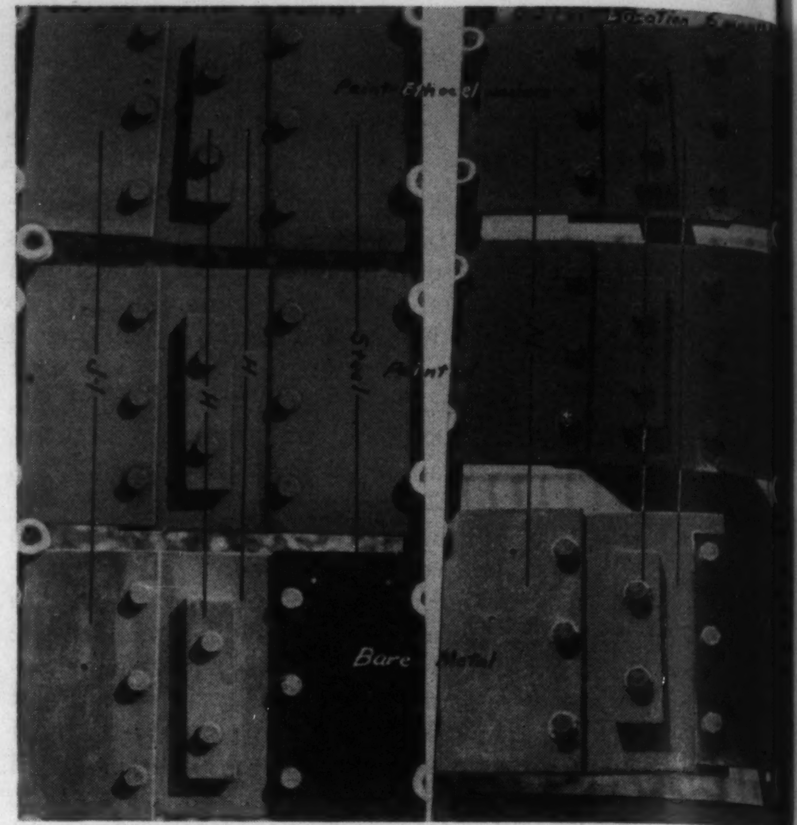


*Fig. 4. Assemblies of magnesium and steel.*

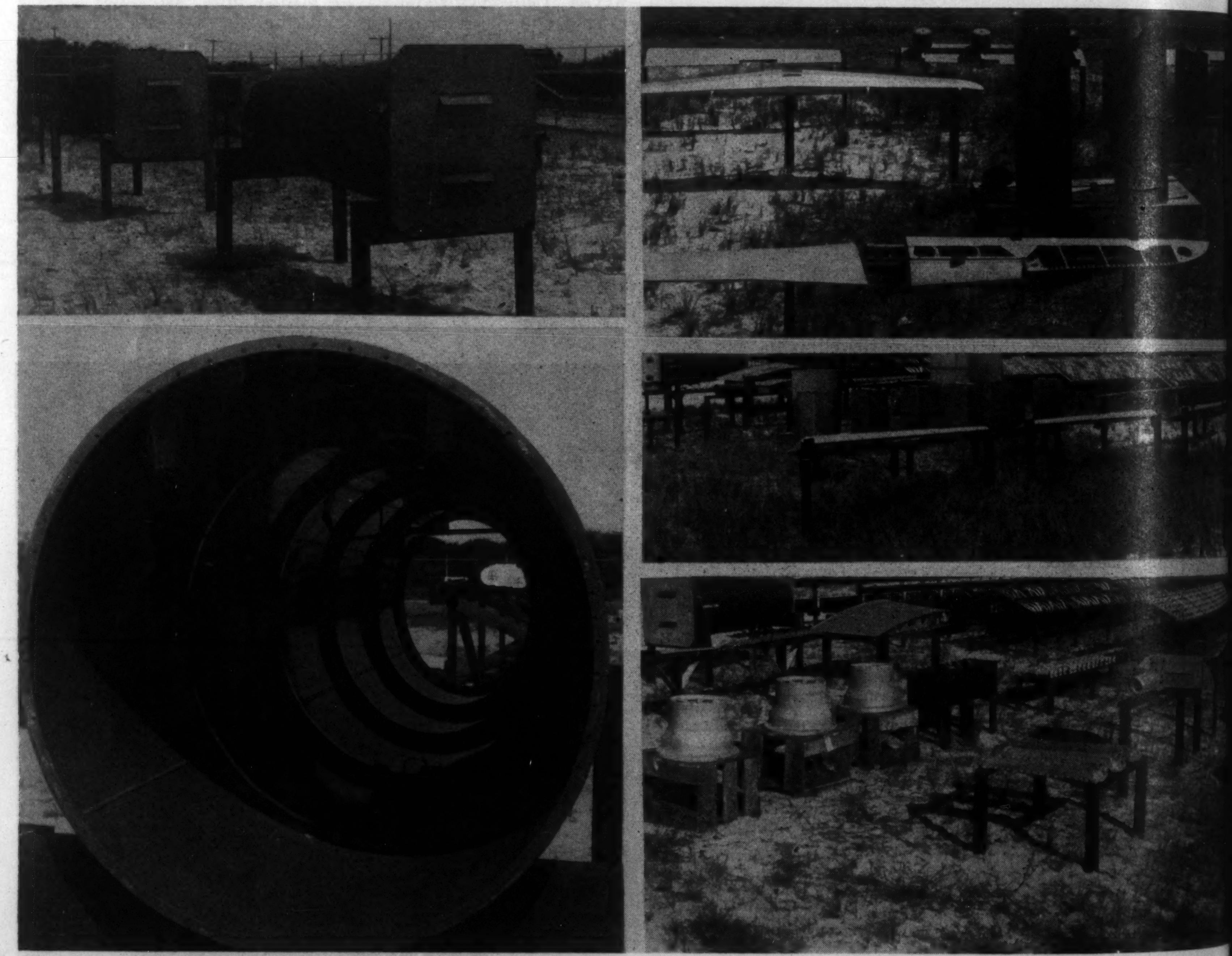


*Fig. 5. Magnesium structures and parts under test.*

as the balance of the sheet. A light buffing with fine abrasive will adequately remove the copper deposit.

*Summary:* High residual or "locked up" stresses due to welding combined with a corrosive atmosphere cause cracking of Dowmetal J-1h. Remedy: Stress relief anneal or *complete* protection. The former is preferable and safer as there are but few cases where a completely impervious paint protection can be obtained.

## Stress Corrosion

Extensive tests of the stress corrosion resistance of various alloys have been carried out in the coastal atmosphere using both direct spring and eccentric loading of test bars. The information thus gained is in addition to that noted above. General conclusions to date based on these sea coast tests are:

(a) For bare (Chrome-Pickle) Dowmetal J-1h, the fracture curve-stress vs. time, levels off at 10,000 to 12,000 p.s.i. in 200 days.

(b) Dowmetal FS-1h is more resistant to stress corrosion than J-1h. At 200 days the stress level is at 18,000 to 20,000 p.s.i. with the curve approximately parallel to that of J-1h.

(c) Dowmetal J-1a is more susceptible to stress corrosion cracking than J-1h.

## Structures and Parts

For comparison with actual service and with test panels, various structures have been placed on exposure. All of the structures are standing up well in this coastal atmosphere after exposure periods up to 2½ yrs. The only exception is in the case of a few "as welded" parts which have developed cracking. The stress relieved mates to these structures are intact. The following tabulation lists the assemblies that are on test as of this writing. (Unless otherwise noted all parts are magnesium.)

1. Three SNJ-2 fabric covered ailerons, one loaded to 1.5g.
2. One SNJ-2 aileron frame—no fabric.
3. P-39 stabilizer.*
4. Arc welded sheet-stringer boxes (simulated booms) with and without stress relief.
5. Two wing sections ("D") one "as welded" and the other stress relieved.
6. "As welded" four foot boom section.
7. P-39 flap.*
8. P-63 elevator (2).*
9. P-63 stabilizer.*
10. A-20 outer panel test section.*
11. High altitude oxygen case.
12. Section of an aircraft oil tank.
13. Three Allison cast engine pans—Dowmetal alloys H, C and Elektron A-9.
14. Three cast bomber wheels—Dowmetal alloys H, C and Elektron A-9.
15. BC-1 outer wing panel—aluminum.
16. P-39 stabilizer—aluminum.
17. SNJ-2 flap.
18. BC-1 wing tip—aluminum.
19. SNJ-2 wing tip.
20. P-61, 10 foot tail boom, machine arc welded.*
21. P-61, 10 foot tail boom, hand arc welded.*

* These parts are experimental designs for the type of airplane indicated.

## Summary

Dowmetal magnesium alloys have been exposed to the coastal atmosphere on the shore of the Atlantic Ocean to obtain information on the corrosion resistance of these alloys which can be used as a guide in the design of light weight structures. Specimens are continually subjected to the corrosive salt atmosphere and at times actually receive direct salt spray.

Under these exposure conditions Dowmetal alloys of the controlled purity type (commercially available in wrought form) are comparable to aluminum alloys 3S and clad 24ST and are superior in appearance to 17ST. All bare Dowmetal alloys are better than unprotected mild steel and are also superior to galvanized iron.

Dow chemical treatment No. 7 furnishes slightly better protection than No. 1 and, at the same time, provides better paint adhesion. Magnesium alloy panels and assemblies which have paints of the lacquer or enamel type properly applied over a chemically treated surface primed with zinc chromate show no paint failure or corrosion after two years of continuous exposure.

Aluminum rivets 2S and A17ST cause galvanic corrosion on magnesium in a coastal atmosphere whereas 56S aluminum rivets produce no such attack. The latter are recommended for riveted Dowmetal structures. Tests on assemblies of magnesium alloys and dissimilar metals showed no galvanic action in the salt atmosphere if protected by suitable junction sealers and paint schedules. Tests of bare metal assemblies indicate severe galvanic corrosion between magnesium alloys and the more noble metals such as copper and steel, while considerably less attack takes place when magnesium alloy contacts aluminum alloys, galvanized iron or zinc.

Arc-welded Dowmetal J-1h sheet must be stress relief annealed to remove the locked-up residual welding stresses which promote stress corrosion cracking. Dowmetal M welds are not subject to stress corrosion cracking and, therefore, do not require stress relief annealing. Spot welds offer satisfactory corrosion resistance if the welding electrodes have been kept clean and the deposition of copper on the sheet material avoided.

Cold forming alone does not induce stress corrosion cracking in Dowmetal J-1h sheet.

Studies of unpainted magnesium alloys exposed to the coastal atmosphere under load show that Dowmetal FS-1h is more resistant to stress corrosion cracking than J-1h. Stresses causing failure in either case are above usual design values.

Exposure of complete magnesium alloy fabricated structures has shown the satisfactory performance of such structures under coastal conditions. In general, it can be concluded that the resistance to corrosion of Dowmetal magnesium alloys has been greatly increased during recent years and that proper design will assure satisfactory service of magnesium alloy assemblies.

# More About Plastics

## A Letter to the Editor—

*To the Editor:* The Materials and Methods Manual in the July issue of METALS AND ALLOYS entitled "Selection of Production Methods for Small Parts" has been read with considerable interest. May we say that we feel you have done an excellent job with a very complicated and somewhat confused subject. It is also our feeling that only by such comparative treatment will it be possible to direct all of these materials and methods into the most appropriate channels.

The criticism and comments which we would like to offer are specific in nature rather than general and arise from the fact that during the last few years a number of special materials and methods have been developed to broaden the scope of the application of plastics. Our comments, all concerned with the information given on plastics, follow:

1.—In the first paragraph on page 95 (e) extrusion, and (f) blowing, have been omitted.

2.—In the second paragraph on page 95 the statement is made "thermosetting materials are usually molded at higher temperature than thermoplastics." This is generally incorrect, for in injection molding, temperatures of over 200 C. (390 F.) are often used.

3.—In paragraph 3 on page 95 in the discussion of urea-formaldehyde compounds some note should be made of the fact that these materials possess excellent arc resistance which is lacking in phenolics.

4.—In paragraph 4 on page 95 polystyrene is listed as "light weight and strong." The light weight is satisfactory as polystyrene is one of the lowest specific gravity materials, but there is considerable doubt in our minds that strength is one of its outstanding characteristics due to polystyrene's inherent brittleness.

5.—Paragraph 5 on page 95 should be corrected in that thermosetting materials are available as jet and transfer molded parts but not as truly injection molded parts.

6.—In paragraph 6 the statement is made that plastic is subject to intricacy limitations. We feel that this should be elucidated further considering some of the very intricate pieces that have been made, and which are probably not as limited as die cast parts.

7.—In paragraph 6 the statement is made that the present plastics are suited to parts having thin walls and uniform sections. This statement should be modified to include such structures as radio housings (3 to 4 ft. in diameter, 3 to 4 ft. high) refrigerator inner doors, and many parts which show considerable variance in the thickness of the walls.

8.—In paragraph 7 dimensional accuracy was stated to be within ±0.005 whereas actually dimensional tolerances of ±0.002 are not at all infrequent.

9.—In paragraph 8 concerning the discussion of the cost of plastic raw materials we feel that the cost per unit volume should be emphasized further, due to the fact most plastics fall in the range of 65 to 75% of the specific gravity of magnesium and 40 to 50% of the specific gravity of aluminum.

10.—In paragraph 9 the statement is made that "the number of strong plastics is still dwarfed by strictly ornamental varieties." This may be partially true but we believe that the comparison should be made upon the basis of the quantities of materials used or the parts made rather than upon the number and type of plastics.

11.—In paragraph 9 the statement is also made that plastics cannot be used over 450 F. This statement should be corrected to allow for the application of G. E. mycalex which is recommended for use up to 650 to 700 F. and various cold mold materials which may be used up to approximately 1000 F.

12.—On page 98 tool and die cost is briefly discussed. This cost should be considered in a fluid state due to the fact that it may be possible to use Masonite dies, low melting alloy dies, plastics dies, and plaster dies, etc.

13.—Under the column "Optimum Lot Size" on page 98 this limit does not hold for low pressure laminating, post-forming of laminates, cast parts and so forth, which may economically be manufactured in comparatively small lots.

14.—On page 100 under the heading "Feasible Complexity" the statement, "quite complex and intricate" should be used instead of the one listed.

15.—On page 101 on the column "Maximum Size," parts weighing 10 to 15 lbs. are being regularly molded by conventional methods, and in low pressure laminating parts weighing anywhere from 3 to 5 times that much have been made.

16.—On page 101 under the heading "Mechanical Properties" some note should be made that in certain plastics the strength-weight ratio is better than for many metals.

17.—On page 103 the statement "working temperatures below 475 F." should be modified in view of our comments in Item 11.

18.—On page 103 under the column "Specific Gravity" the spread should be 1.05 to 3.6 to include polystyrene and G. E. mycalex.

19.—On page 103 the top tensile strength limits should be raised to 30,000 to 40,000 p.s.i.

In conclusion may we reiterate that we feel that the article was excellently prepared and is very informative, but that the main difficulty has been that due cognizance has not been taken of the more unusual plastics. We trust that you will find these comments of interest.

J. J. PYLE, Chemist and Director
WYMAN GOSS, Compound Group Leader

Plastics Laboratory,
General Electric Co.,
Pittsfield, Mass.

# MATERIALS & METHODS MANUAL

# 6

This is another in a series of Manuals on engineering materials and production methods, published at periodic intervals as special sections in Metals and Alloys. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal-forms or with essential principles, best procedures and operating data for performing specific metal-working processes.

# Heat Treatment of Steel

## as Related to Design Materials and Processing

**by THOMAS F. O'BRIEN**

Metallurgical Engineer, The A. F. Holden Co., New Haven, Conn.

Successful heat treating and the attainment of highest quality in heat treated steel parts depends not only on the heat treater and metallurgist but also on those who design the parts, select the materials for them and plan and operate the other production processes. The design engineer, the materials engineer and the production engineer or executive thus cannot help but improve their own jobs and make infinitely lighter the burden of the heat treater as well with a clearer understanding of the close relationship between heat treatment on one hand and design, materials and overall processing on the other. In this Manual the author clearly demonstrates that relationship and includes several human-interest examples, together with much helpful information on modern heat treating that design, materials and production engineers will find highly useful.

**Contents**

Introduction: The Common Problem . . . . Page 1336
Design and Heat Treatment . . . . . . Page 1336
Materials Engineering and Heat Treatment . . Page 1339
General Processing and Heat Treatment . . Page 1343
Progress in Methods and Equipment . . . . Page 1345
Conclusion: The Personal Equation . . . . Page 1350

**Metals and Alloys, May 1945**

# MATERIALS & METHODS MANUAL 6

## Introduction: The Common Problem

The tremendous impetus given to engineering and technology by the onslaught of World War II has cut its mark more deeply on the metal-working industries than on any other single type of manufacturing. The conversion from peace-time to war-time production efforts brought about many twists and wrinkles in manufacturing and processing that were entirely new and awesome to the previously uninitiated.

Among the metal-working arts, especially in the field of processing, few have been pushed forward to such a position of unwonted prominence as that of the heat treatment of metals. We designedly say "pushed," for its advancement to its present position of importance has not been received as graciously as it could or should have been. Unfortunately, and too frequently, heat treating is accepted as an unwanted step-child, a necessary evil, by many manufacturers; by some because the field of endeavor was entirely new and unintelligible to them, by others because their knowledge has not kept pace with rapid strides being made daily in methods and processes. But unwonted or unwanted, heat treating, like the income tax, is definitely here to stay.

One of the stories of Biblical history has it that King Solomon, upon the completion of his magnificent temple in Jerusalem, sought to pay honor to the artisan who had contributed most towards the construction of his monument. He settled upon the blacksmith for his having wrought the tools without which none of the others could have labored. In the days of the mighty smith, and up until not too long ago, the man who made the tools and the man who hardened them were one and the same. But with the need of mass production and the advent of specialization, the making of tools subsequently was split up into four domains: those of (1) The design engineer, (2) The materials engineer, (3) The machinist, and (4) The heat treater.

Too frequently none of the four has a full knowledge of the others' problems, with the result that the products of their combined efforts sometimes leave much to be desired. Some or all may be at fault in the failure of a particular job—but, speaking apologetically, and from universal experience, more often than is his due, the heat treater gets it in the neck; he inherits the headaches—but without honor.

The purpose of this Manual is, therefore, an appraisal of those sources of difficulty that any heat treater—but more particularly the commercial heat treater—accepts as his daily part in his phase of processing, a job but which can be corrected by better design, materials or process engineering. It is expressed from the heat treater's point of view, with the hope that the manufacturer may appreciate the conditions that render good heat treating difficult, if not impossible, and that it may stimulate some thought and responsibility for the correction of these conditions.

The ensuing discussion is not aimed so much at those fabricators whose plants are so integrated that collaboration among all four departments mentioned leads to consistent production of jobs high in quality and quantity, as at (1) small jobbing shops where engineering, especially along metallurgical lines, may be inadequate, and (2) large plants bureaucratized to the state where interdepartmental consultation on a job would be considered a sign of mutual weakness and inability. Both entities do exist, as any heat treater will attest.

It is seldom that one individual is an expert in design, in material selection, in machining, and heat treating. Nor is it desirable to take the time of a good engineer or machinist to turn him into a poor heat treater, or vice versa. But a common meeting ground could be prepared if all of them had in mind some of the basic principles of the evaluation and application of metallic materials—which are after all the foundation and prime matter of their operations.

The heat treater, insofar as he is presumed to be a metallurgist, has a knowledge of such principles. If these principles could be expressed in everyday terms that engineers could follow without having to learn all the technical terminology of metallurgy, which is likely to be jargon to the engineer, then they might be better able to put the right questions to the heat treater and vice versa.

Conversely, the heat treater may be unfamiliar with the fine points of manufacture and production. Each lacks the background of the other and often is not too conversant with the technical terminology and problems of the other. Rarely is the heat treater informed of the exact purpose of a tool or a part to be heat treated; less often does he have full knowledge of performance and failure records, or full appreciation of the conditions of normal and abnormal service.

On the other hand, the engineer may not have too intimate knowledge of the metallurgical behavior of new alloys in the tool and structural field; consequently he cannot predict the behavior of a certain alloy, either in its response to heat treatment, or in its subsequent performance. From the materials standpoint there is a too prevalent desire among engineers for a reference book to which they could turn for the way out of any particular dilemma, without bothering to think the matter out or to take counsel. This cookbook attitude is a very dangerous one, rivalled only by that of the engineer who would use one material for all jobs, regardless of purpose or adaptability.

We could further complicate the problem by the introduction of the testing engineer or the specification engineer, but it must be presumed from the heat treater's standpoint that the specifications as he receives them are correct for a given job. With these general ideas in mind, then, it is hoped to discuss heat-treating problems from the standpoint of design, materials, and machining practice.

## Design and Heat Treatment

In processing any tool or part, the heat treater aims at obtaining certain specified physical properties in the metal by controlled cycles of heating and cooling—at the same time avoiding warpage and distortion, fixed volume changes, and, above all, cracking. The avoidance of these three pitfalls is the secondary aim of the heat treater, his primary aim being the processing of a tool or part that will stand up under service. In the heat treatment of the steel part, he must reckon with the chemical analysis of the steel, the quality of the metal, and the specified heat treatment. Ordinarily the first two factors are beyond the control of the heat treater.

Failure of the part will occur by cracking when a combination of forces exceeds the ultimate strength of the metal. Such forces may be the internal stresses set up by fabrication of the part, the internal stresses that are a necessary concomitant to heat treatment, and the external forces to which the part is subjected in service. Sometimes the combination of internal forces exceeds the strength of the metal and the part cracks in heat treating; or they may be developed to the degree where the net result of stress vs. strength may cause warpage and distortion to a serious degree.

Again the internal strains may approximate a large percentage of the total strength, and failure may occur under relatively light service loads. It is axiomatic then that the workable strength of the part is inversely proportional to the internal strains induced in the metal, in heat treatment, at least.

### Internal Strains

Internal strains are set up in a metal by a variety of causes, some of which will be discussed later. The principal and most serious strains are those induced by quenching, by reason of the differential cooling. The temperature gradient set up in cooling, *i.e.,* the differential in temperature over a unit distance of the metal, is largely a function of the size and shape of the piece quenched, in other words, the design.

Variations in cooling rate, by reason of mass effect, produce variations in the atomic patterns, and each structural component produced by the cooling gradient passes through a volume change to a fixed density. An atomic tug-of-war goes on during the complete cooling cycle and unless the outcome is an absolute draw, the metal suffers in proportion to the various degrees of strains set up. The fundamental precept in good design (for heat treatment, at least) is to project and fabricate shapes and sizes that will keep the temperature gradient throughout the whole piece at a minimum during quenching.

The ideal condition would be a cooling rate uniform to the extent that the whole mass of metal would be cooled at the same speed. Such a condition is naturally impossible, nor would it necessarily produce the most serviceable unit in each particular instance. But the most practicable condition is well summed up by Palmer ("Metals Handbook," Amer. Soc. for Metals, 1939, p. 215) as follows: "A part is properly designed, from a standpoint of heat treatment, when the entire piece may be heated and cooled at approximately the same rate during the heat-treating operation. Perfec-

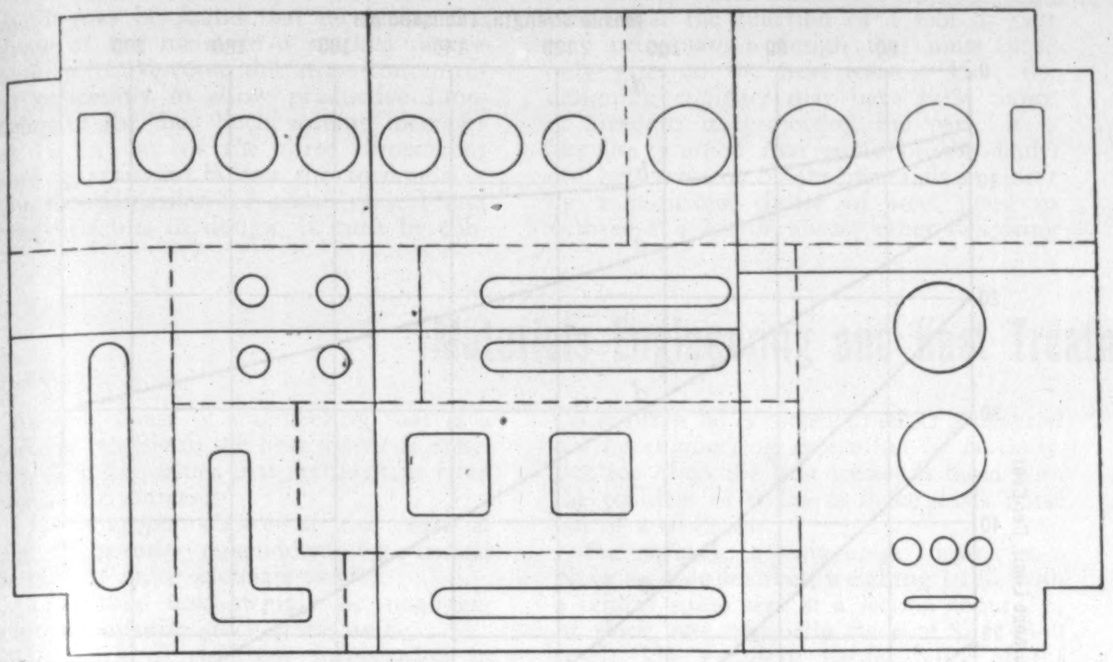


*Fig. 1. Plan view of radio sub-base blanking die. Heavy black lines denote sectioning as designed. Broken lines suggest sectioning to insure better distribution and uniform cooling in heat treatment.*

tion in this regard is unattainable because, even on a sphere, the surface cools more rapidly than the interior. The designer should, however, attempt to so shape his parts that they will heat and cool as uniformly as possible. The greater the temperature difference between any two points on a given part during quenching, and the closer these two points are together, the greater will be the internal strain and, therefore, the poorer the design."

## Design Factors and Faults

In violation of this law, pieces are designed and actually submitted for heat treatment that are vaguely reminiscent of that spurious verse that made the rounds of all the engineering departments and tool shops at the beginning of the defense program. It was published in this magazine in Feb. 1942, p. 264. Here it is:.

### The Successful Designer

The designer bent across his board,
Wonderful things in his head were stored,
And he said as he rubbed his throbbing bean,
"How can I make this thing tough to
machine?
If this part here were only straight
I'm sure the thing would work first rate,
But 'twould be so easy to turn and bore
It never would make the machinists sore.
I'd better put in a right angle there
Then watch those babies tear their hair.
Now I'll put the holes that hold the cap
Way down in here where they're hard to tap.
Now this piece won't work, I'll bet a buck,
For it can't be held in a shoe or chuck;
It can't be drilled or it can't be ground,
In fact the design is exceedingly sound."
He looked again and cried, "At last!
Success is mine, it can't even be cast."

If it cannot be cast, it certainly cannot be heat treated. The verse through its humorous exaggeration, emphasizes the prevalent faults in engineering design. But from the standpoint of heat treating, they are many and varied, and all of them stem from the violation or failure to observe the fundamental principle outlined above. The following are typical:

## Design Factors and Faults

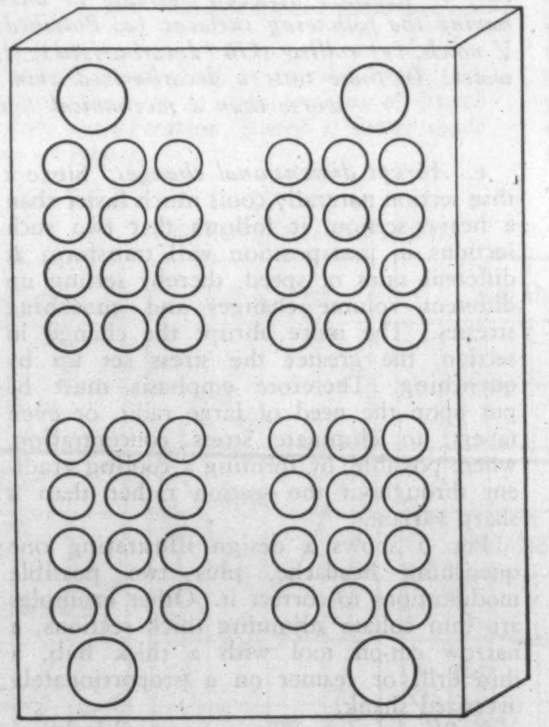
a. *Unbalanced sections:* Large blanking dies, such as are used for stamping radio sub-bases and similar parts, are usually made in several sections, so as to facilitate machining of the die sections, and permit engineering changes or repair work. The heat treater readily appreciates such sectioning of large dies because it materially aids his handling problem and reduces potentially serious volume changes. But too frequently such sectioning is designed arbitrarily; the component parts may be symmetric, but not much thought given to uniform cooling or balance in heating and cooling. Fig. 1 shows the sectioning of an actual die, (heavy lines) together with a more judicious sectioning (broken lines) that would guarantee more uniform cooling and better load distribution.

b. *Lightening holes:* Balance and uniformity can likewise be obtained in design by the judicious inclusion of lightening holes in a single die piece, so as to permit more uniform cooling and prevent shrinkage and/or expansion. Fig. 2 (a) shows a die presented for hardening, while Fig. 2 (b) shows the same die after inclusion of lightening holes inserted at the heat treater's suggestion.

c. *Stress equalizers:* Close akin to lightening holes in principle is the addition of extra holes or keyways in circular sections, or in bushings, rings, sleeves, etc., solely to equalize the sections and prevent possible eccentricity in a severe quench. One possible method is exemplified in Fig. 3a and 3b.

d. *Sharp angles and corners vs. fillets and radii:* Probably the most common and egregious error committed in design is failure to insert radii or fillets wherever possible in corners or re-entrant angles. At such points it is difficult to get uniform cooling. Heat is constantly being supplied from the heavier adjoining sections since the cooling area is so much smaller at the angle. The inaccessibility thus confronting the coolant results in a slower quench, with danger of vapor pockets excluding it altogether. Heavy internal strains of differential cooling are thereby set up at a point certain to receive stress concentration in actual operation.

The importance of even a small radius will lessen if not eliminate danger of cracking, especially in steels where water quenching is necessary to obtain desired properties.



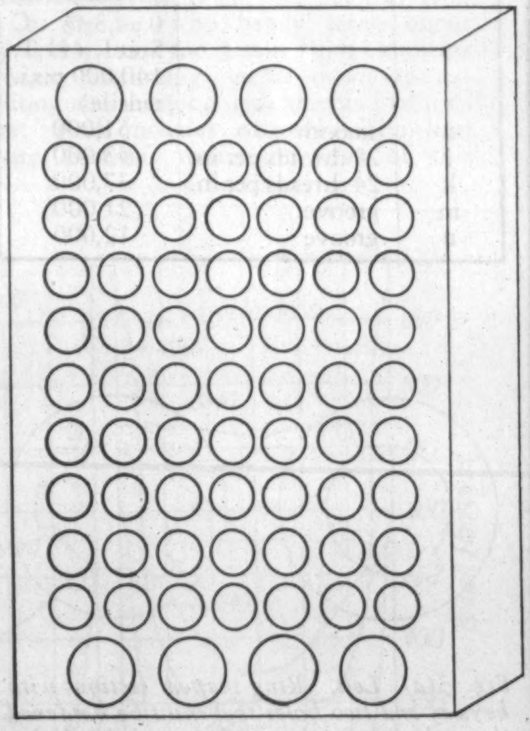


*Fig. 2(a). Left. Piercing die showing relatively light honey combed sections and heavier ribbed sections. Unequal cooling may cause shrinkage and expansion thereby throwing holes out of tolerance.*

*Fig. 2(b). Right. Same die with addition of lightening holes calculated to minimize volume changes and maintain tolerances.*

Table 1 lists the results obtained by fatigue tests on two heat-treated steels, SAE 6150 at 137,500 p.s.i., and on a 0.43% C steel treated to 140,000 p.s.i. tensile.

While the analogy of design with relation to heat treatment and fatigue testing is far from perfect, it is quite obvious from the results obtained that the potential stresses and strains developed in heat treatment are influenced by these design factors. To go a step further on fatigue tests, Fig. 4 shows the relationship of endurance limit and tensile strength as influenced by surface condition of a metal. Both the designing and processing engineer will do well to study the importance of finish from the standpoint of surface stresses set up in the heat-treating operation and stresses developed in actual service.

*Table 1.—Results Obtained from an Alloy and Plain Carbon Steel Subjected to Fatigue Tests after Heat Treatment, with Specimens Designed as in Fig. 4 (after R. R. Moore).*

| *Specimen in Fig. 4* | *Fillet Radius, Notch, Thread, or Groove* | *Endurance Limit p.s.i.* |
|---|---|---|
| | | SAE 6150 (H.T. 137,500 p.s.i. tensile) |
| a | 9.85 in. | 55,000 |
| j | ¼ in. | 45,000 |
| i | ⅛ in. | 42,000 |
| h | 1/16 in. | 36,000 |
| f | 1/64 in. shallow | 25,000 |
| c | 1/64 in. medium | 24,000 |
| e | 1/64 in. deep | 22,000 |
| c | sharp shallow | 24,000 |
| b | sharp deep | 21,000 |
| | | 0.43% C Steel (H.T. 140,000 p.s.i. tensile) |
| a | smooth | 51,000 |
| l | 28 threads per in. | 43,000 |
| k | 24 threads per in. | 37,000 |
| m | groove | 21,000 |
| n | groove | 12,000 |

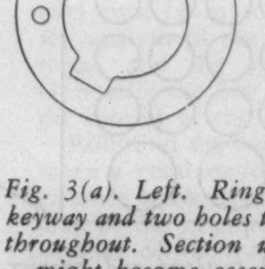


*Fig. 3(a). Left. Ring-shaped section with keyway and two holes that must be hardened throughout. Section unbalanced in design might become eccentric in quenching.*

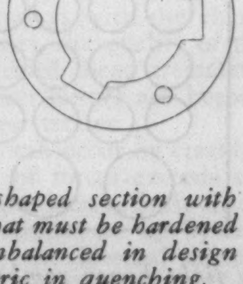


*Fig. 3(b). Right. Same section with one hole and two keyways added to render section more uniform in heating and cooling.*

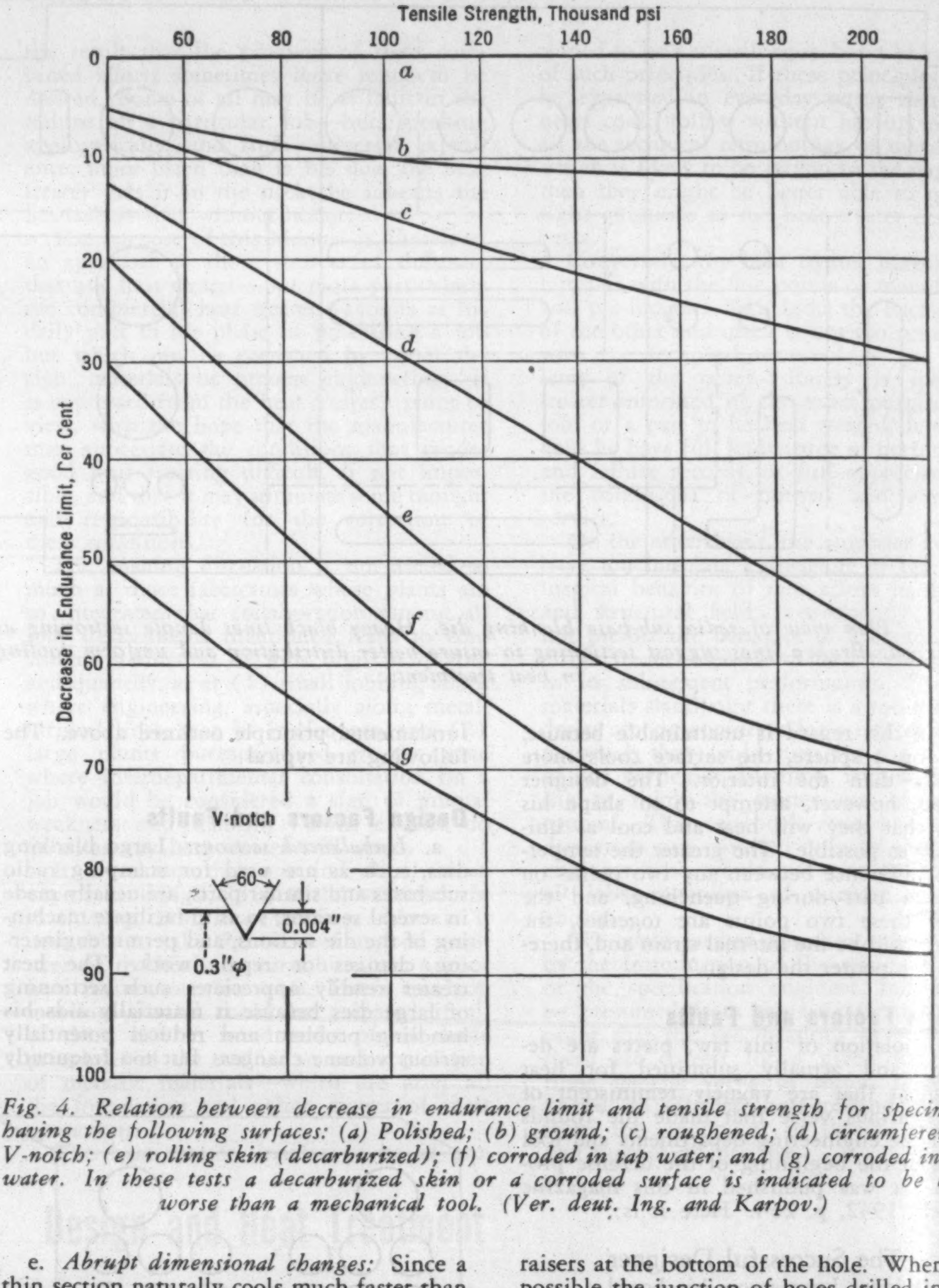


*Fig. 4. Relation between decrease in endurance limit and tensile strength for specimens having the following surfaces: (a) Polished; (b) ground; (c) roughened; (d) circumferential V-notch; (e) rolling skin (decarburized); (f) corroded in tap water; and (g) corroded in salt water. In these tests a decarburized skin or a corroded surface is indicated to be even worse than a mechanical tool. (Ver. deut. Ing. and Karpov.)*

e. *Abrupt dimensional changes:* Since a thin section naturally cools much faster than a heavy section, it follows that two such sections in juxtaposition will transform at different rates of speed, thereby setting up different volume changes and quenching stresses. The more abrupt the change in section, the greater the stress set up by quenching. Therefore emphasis must be put upon the need of large radii, or even tapers, to eliminate stress concentration, where possible, by forming a cooling gradient throughout the section rather than a sharp variant.

Fig. 5 shows a design illustrating one quenching headache, plus two possible modifications to correct it. Other examples are thin collars adjoining thick sections, a narrow cut-off tool with a thick hub, a thin drill or reamer on a proportionately oversized shank.

f. *Blind holes:* Wherever possible blind holes, for whatever purpose used, should be eliminated. Continuation of the hole through a piece, *e.g.*, a large reamer, will make for greater uniformity in cooling and better balance under stress, and eliminate the usual sharp corners occurring as stress-raisers at the bottom of the hole. Wherever possible the junction of holes drilled into a piece should be avoided since the intersection will always remain as a stress-raiser even though packing the holes in heat treatment lessons the danger of cracking.

g. *Wall thickness:* In a balanced design holes should not be drilled in too close proximity to one another, nor placed so near cut-out sections or the sides of the section that the remaining wall thickness is seriously endangered. Even though the heat treater tries to equalize the cooling rate by packing the holes for treating it, this is not always a sure guarantee against possible failure. Frequently, designs are made for a part to be carburized wherein the wall thickness between holes, or from holes to the edge, is found to be inadequate to support the desired case depth. Quenching such a part is extremely dangerous by reason of the high carbon case and the low carbon base metal with their varying rates of expansion and contraction.

h. *Material thickness:* Occasionally a die that must of necessity have sharp corners and re-entrant angles may fail in service at one or more points of stress concentration. It may be found that increasing the volume of the metal to a marked degree may help to overcome this stress concentration sufficiently to allow productive functioning of the die. Such volume increases may be in any of the three dimensions found necessary to bolster the weakness.

In the discussion of some typical and prevalent faults in design, it must be conceded that the function of a tool or part may necessitate a design that must cause only grief to the heat treater. Here the designing engineer may have little choice or freedom in projecting the part. It is likewise granted that some of the faults can be overcome by the materials engineer by a judicious choice of steel fitted to withstand a lot of abuse; other designing faults may be overcome by careful handling and technique in the heat treatment of the part. But the best efforts of the materials engineer and the heat treater cannot always cover up the fact that the design may be fundamentally faulty. This is another case where two rights, like two wrongs, do not make a third right. Design is clearly no less important than materials and processing.

## Materials Engineering and Heat Treatment

Another phase of engineering that is a source of trouble to the heat treater is materials. The difficulties that accrue stem from three main sources:

(1) Improper choice of the material used, frequently engendered by critical shortage of more adequate steels;

(2) Either unknowingly or negligent failure to identify stock piles; and

(3) Lack of sufficient information to the heat treater as to analysis and quality of the steel used.

### Selection of Material

We are in complete sympathy with the materials engineer, and his problem of the critical shortages of tried and true analyses. Quite often he is forced to select a material not by engineering choice but by necessity. But too often the heat treater is faced with the problem of trying to make a silk purse out of a sow's ear.

For example, a wing hinge forging on a Navy torpedo bomber, weighing 14 lb. with a critical stress area at a section about 2¾ in. thick, was originally made of SAE 4340 steel. The excellent hardenability of the alloy readily responded to the specifications of 180,000 p.s.i. min. U.T.S. Due to shortages of 4340, the material specifications were changed to 4140 and subsequently to 4130—without any change in tensile specifications or design of the part. Add to this substitution the inevitable low carbon content that showed up in the 4130 and failure to identify the substitute materials—and you have a real heat-treating headache.

No one can object to material substitutions, provided that the substitute offers as great hardenability or response to heat treatment. But in the instance cited, 4130 was never really designed for this job; this was an arbitrary substitution that could have been and should have been fought against on the basis of a number of engineering principles, especially since the part is one of the most highly stressed on the plane. Yet it is not infrequent that heavy sections (e.g. bolts, 2 in. diam. by 18 in. long) designed for 200,000 p.s.i. U.T.S. are made of 4130.

It is quite possible to get a surface Rockwell Hardness on any such specified part but one should hesitate to aver that the physical properties specified are actually obtained. Factors of mass effect and increased size should be considered in the light of carbon content and alloying elements. These instances are typical of many like them.

### Types and Terminology of Steel

Much of the confusion brought about in the choice of materials resolves itself down to a matter of terminology. To the materials engineer (properly so called) this discussion may seem puerile; but the number of people, who bandy terms about improperly, runs the gamut from engineers through purchasing agents down to expediting and shipping departments [Editor's note: And includes editors]. The heat treater becomes quite conscious of this

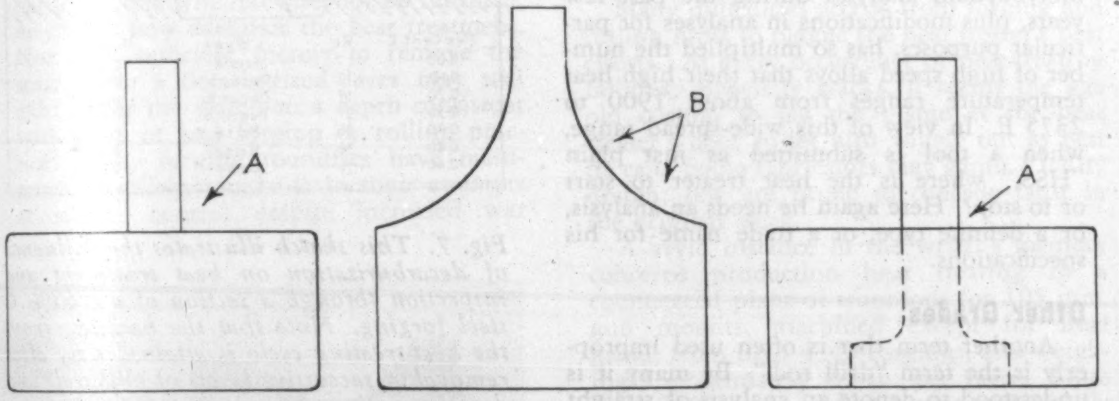


*Fig. 5. Abrupt dimensional change in the punch at left, plus sharp re-entrant angle (A), can be modified by the large radius (B) tapering from heavier to thin sections of punch (as in middle elevation). If sharp angle A is necessary for operation, punch is better made in two parts (as shown at right).*

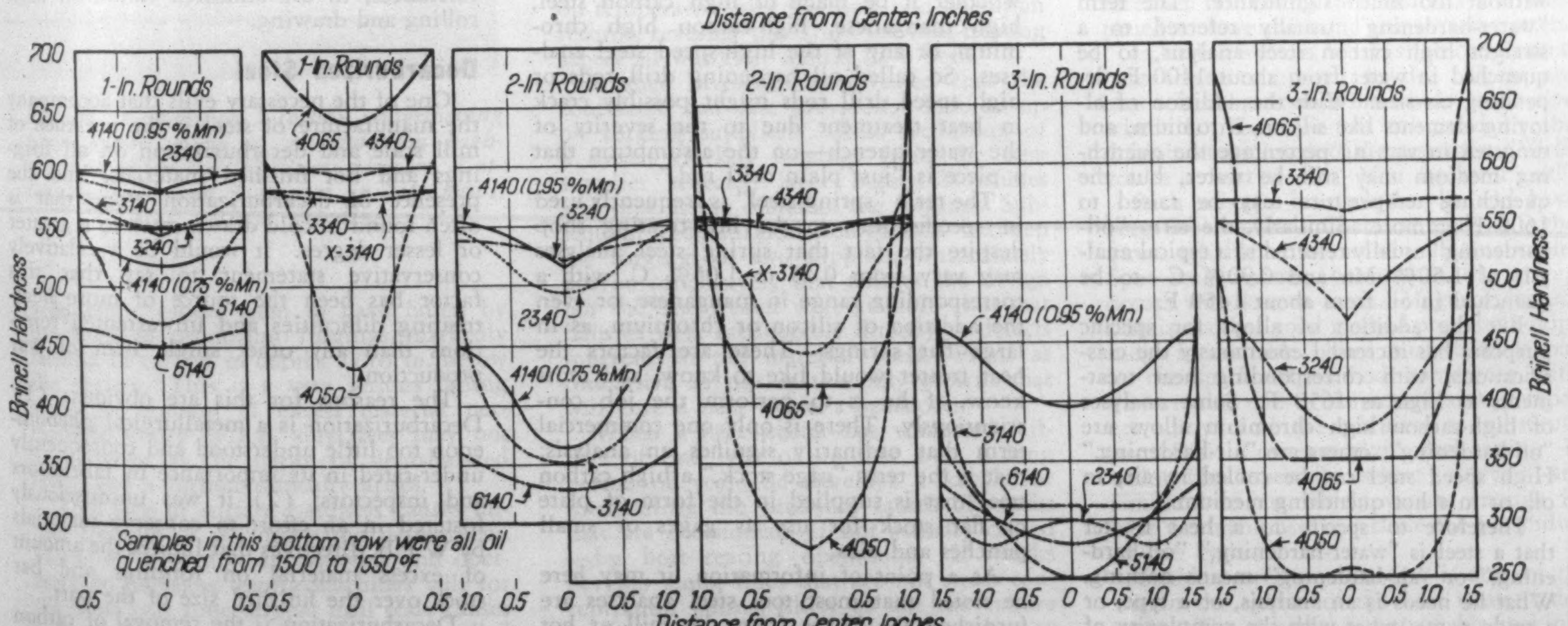


*Fig. 6. Hardening characteristics of some common alloy steels containing 0.40 to 0.65% C.*

when he tries to obtain information on the steel submitted. It involves the significance and use of such terms as "water-hardening" and "oil-hardening"; "high speed steel"; "tool steel" and "structural steel"; "drill rod" and "gage stock"; "hot rolled" and "cold rolled" steels; "mill scale" and "decarburization." To refute the vague notion among some that "steel is steel" it may be necessary to start from scratch:

Steel is generally divided into four categories, depending on its purpose:

(1) Tool steels (any steels used for cutting, forming, or working other materials);
(2) Structural or engineering steels (any steels used for structures, machines, assemblies, etc.);
(3) Electrical steels (special alloys used by reason of electrical conductivity, etc.);
(4) Stainless steels (used for ornamental purposes or resistance to corrosion or because of their strength-weight properties).

The terms "hot rolled" and "cold rolled" do *not* refer to any chemical analysis of steel; any given analysis may be either hot or cold rolled, depending on whether the final passes through the rolling mill to a finished size are conducted on the steel in a hot or cold state. Too frequently "cold rolled" steel is a term used to denote low carbon steel, also called "boiler plate," "tank plate," or better, "machine steel." Since many alloy structural steels are rolled or drawn cold, the term "cold rolled" leads to confusion; it refers neither to an analysis nor a shape, but to a *finish* on the metal. Most of what has been said refers likewise to the term "hot rolled."

## Tool Steels

Tool steels are sometimes divided for convenience into four classifications: Water-hardening, oil-hardening, air-hardening and high-speed steels. The first three are classed by reason of their cooling medium or quench; the last is so named by reason of the fact that it is capable of maintaining its hardness and/or cutting edge at the relatively high temperatures produced by machines operating at "high speeds." This classification was formerly based on analyses of steel.

But such a basis has long since been outmoded, and the terms are arbitrary and without too much significance. The term "water-hardening" usually referred to a straight high carbon steel analysis, to be quenched in water from about 1400 F, depending on size. With the addition of alloying elements like silicon, chromium, and tungsten in varying percentage the quenching medium may still be water, but the quenching temperature may be raised to 1600 F or more. Similarly, the term "oil-hardening" usually referred to a typical analysis of 1.50% Mn and 0.90% C—to be quenched in oil from about 1450 F.

But the addition of alloys for specific purposes has increased enormously the classifications, with corresponding heat treatments as high as 1650 F. Some analyses of high-carbon high chromium alloys are "oil-hardening"; others are "air-hardening." High speed steel can be cooled in air, in oil, or in a hot quenching medium.

Therefore to specify to a heat treater that a steel is "water-hardening," "oil-hardening," or "air-hardening" means nothing. What he needs is an analysis, or a type, or a trade name; what with the complexity of modern alloys and their own peculiar criticals, the designation of the quenching medium loses its significance.

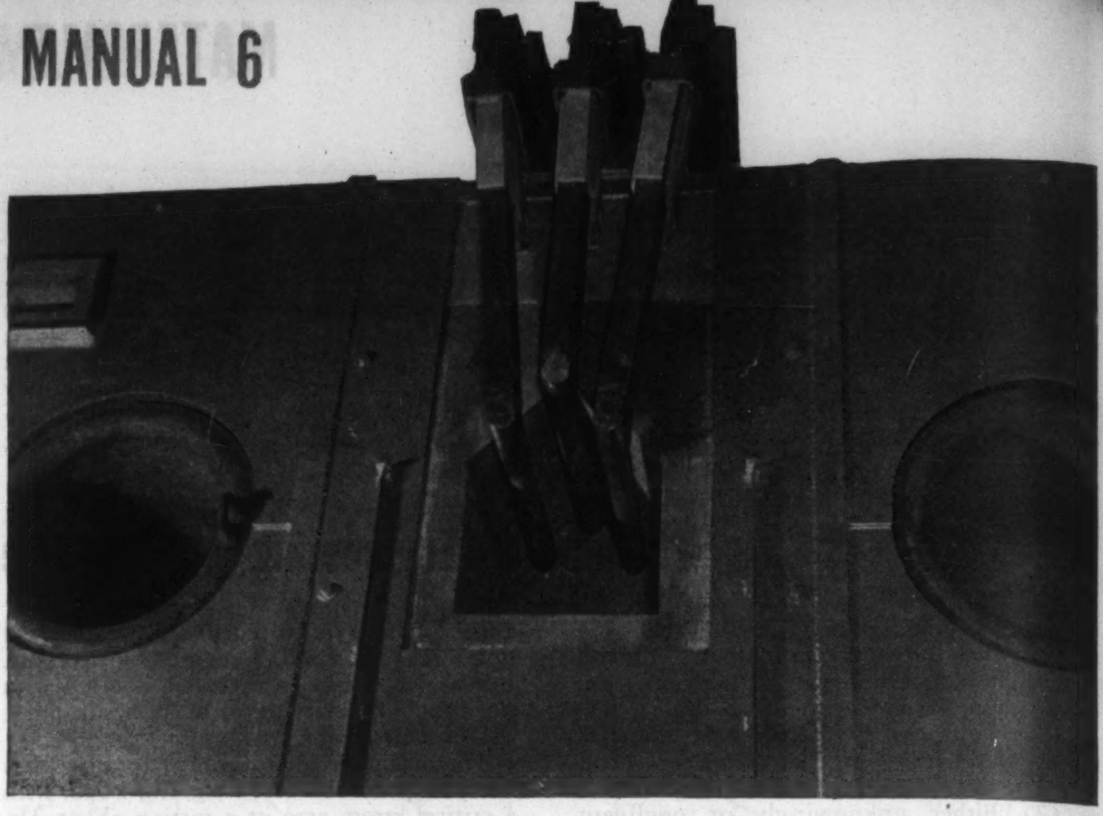


*Fig. 8. Overhead view of a salt bath furnace for heat treatment of high-speed steels, a 3-in-1 unit consisting of pre-heat (left) and quench (right), gas or oil-fired, and immersed electrode high heat section with 5-sided ceramic pot.*

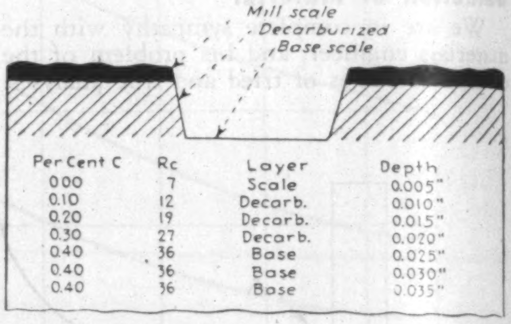
The term "high speed" steel, when used alone, formerly signified a definite type, the so called 18-4-1 analysis, and a definite heat-treating cycle. The rapid influx of molybdenum analyses during the past few years, plus modifications in analyses for particular purposes, has so multiplied the number of high speed alloys that their high heat temperature ranges from about 1900 to 2375 F. In view of this wide-spread range, when a tool is submitted as just plain "HSS," where is the heat treater to start or to stop? Here again he needs an analysis, or a definite type, or a trade name for his specifications.

## Other Grades

Another term that is often used improperly is the term "drill rod." By many it is understood to denote an analysis of straight high carbon steel used as a "water hardening steel" in the manufacture of punches, pins, drills, dowels, etc. This is only partly true. Drill rod refers not to an analysis, but to a *shape* of steel, a centerless-ground tool steel for use as drills and round shapes, whether it be made of high carbon steel, high manganese, high-carbon high chromium, or any of the high-speed steel analyses. So called oil hardening drill rods or high speed drill rods might possibly crack in heat treatment due to the severity of the water quench—on the assumption that a piece is "just plain drill rod."

The term "spring steel" is frequently used in specifications to the heat-treating shop despite the fact that spring steel analyses may vary from 0.45 to 1.05% C, with a corresponding range in manganese, or even the addition of silicon or chromium, as in large flat springs. These are factors the heat treater would like to know, and must know, if he is to perform the job conscientiously. There is only one commercial term that ordinarily signifies an analysis; that is the term "gage stock," a high carbon steel that is supplied in the form of plate or flat stock for use as gages or small punches and dies.

As a point of information, it may here be noted that most tool steel analyses are furnished the buyer from the mill as hot rolled and annealed, with the exception of certain wire and strip that are cold drawn or rolled to certain hardnesses, and gage stock and drill rod that are machined and ground, respectively, to certain dimensional tolerances, in the annealed condition after rolling and drawing.



| Per Cent C | Rc | Layer | Depth |
|---|---|---|---|
| 0.00 | 7 | Scale | 0.005" |
| 0.10 | 12 | Decarb. | 0.010" |
| 0.20 | 19 | Decarb. | 0.015" |
| 0.30 | 27 | Decarb. | 0.020" |
| 0.40 | 36 | Base | 0.025" |
| 0.40 | 36 | Base | 0.030" |
| 0.40 | 36 | Base | 0.035" |

*Fig. 7. This sketch illustrates the influence of decarburization on heat treatment and inspection through a section of a 0.40% C steel forging. Note that the hardness from the heat-treating cycle is attained only after removal of successive layers of mill scale and decarburization shown in the cut-out. Compare carbon percentages and Rockwell C hardness checks with depth of cuts.*

## Decarburized Steel

One of the necessary evils that accompany the manufacture of steel is the presence of mill scale and decarburization on all forgings and hot finished materials, and the presence of decarburization alone that is often found in cold drawn stock to a greater or lesser degree. It would be a relatively conservative statement to say that this factor has been the source of more heat-treating difficulties and unwarranted rejections than any other single item of war production.

The reasons for this are obvious: (1) Decarburization is a metallurgical phenomenon too little understood and consequently under-rated in its importance by fabricators and inspectors; (2) it was unconsciously fostered in an effort to conserve materials by W.P.B. directives that limited the amount of excess material on forgings and bar stock over the finished size of the part.

Decarburization is the removal of carbon from the solid surface of steel by the normally oxidizing reaction of media with which the steel comes in contact. When steel is forged and rolled in a hot condition, or reheated for any purpose in pits or furnaces without controlled atmosphere, the air reacts with the surface of the steel in the hot state, the oxygen combines with the iron, and the carbon, rooted from its anchor, tends to migrate from the surface. The amount of decarburization is dependent upon time, temperature and atmospheric conditions, but in any event the amount of carbon removed is a gradient from the original carbon content of the steel to a relatively carbon free iron matrix which is coated with the so-called mill scale.

Many identify decarburization with mill scale; they are not identical Mill scale is only one phase of decarburization, the external phase. Underneath the mill scale, decarburized material (*i.e.* iron robbed of carbon) may and usually does exist.

So much for hot rolled materials. Now this same decarburized metal can be passed on to the cold rolled or cold drawn stock. It may be elongated, or thinned out, but it is there, in amounts depending on the condition of the original hot rolled stock and the number of passes in the mill.

The presence of this decarburized material lends itself to difficulties and headaches in heat treatment if only from the standpoint of inspection. Since carbon is the principal hardening element in steel, the absence of carbon merely means less hardness and hardenability. Unless this decarburized material is machined off uniformly, hardness tests will likewise not be uniform, no matter how adequate the heat treatment. Nor is it sufficient merely to remove the scale, since a decarburized layer may still exist under the scale—to a depth consistent with good or bad forging or rolling practice. Many forging foundries have maintained excellent standards in their attempts at surface control despite increased war production; others seem to have fallen by the wayside producing forgings markedly lacking in carbon to depths 1/16 in. below the surface. This is a very serious failing since the amount of excess material permissible under W.P.B. directives may not be as great as the depth of decarburized layer, and a further difficulty arises.

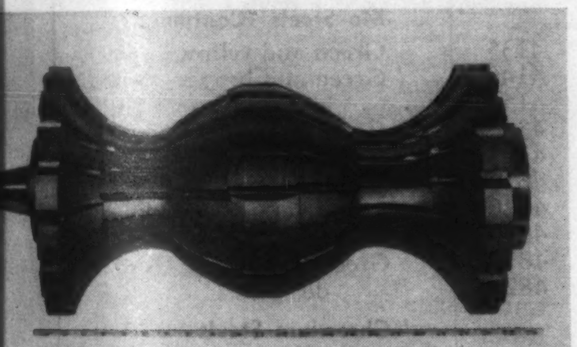


*Fig. 9. Composite 7-section interlocking form cutter, made of molybdenum high-speed steel for milling Roots blowers. Cutter hardened and tempered in salt baths, used without grinding.*

This lack of surface hardness causes untold troubles in the inspection department. Heads of inspection departments and operators on hardness testing machines will for the most part concede that mill scale causes low readings on forgings and hot rolled materials. But most of them refuse to admit that the decarburized layer underneath the mill scale can cause readings sometimes equally as low.

On parts which present a surface machined well below the soft layer no difficulty presents itself—until one meets with that type of inspector who arbitrarily insists that readings throughout an entire surface should be of uniform hardness on both machined and unmachined surfaces. This arbitrary attitude is sometimes shared, unfortunately, by some government inspectors who, despite formal training in metallurgical inspection, do not seem to comprehend this factor of decarburization.

Another source of inspection difficulty is the engineer who specifies on a blueprint that Brinell hardness tests be taken on an unmachined surface of a forging, with the mistaken idea that a Brinell test, by reason of its greater penetration area and greater load, can compensate for any soft surface. All things being equal, in this instance a Brinell might be more reliable than a Rockwell hardness test, but it is not accurate until the surface has been properly prepared.

This discussion of fundamental inspection principles may seem to some to belabor the obvious; but if inspection departments on the whole recognize the precepts, they too frequently fail to abide by them. Other aspects of this decarburization phase will be discussed under machining difficulties.

## Mill History of a Material

Many difficulties accrue from forging and rolling mills to plague the heat treater's best efforts. At every occurrence of heat-treating failures, especially cracks, it seems the age old custom to lay the blame at the heat treater's door to let him wiggle out as best he can. Some fabricators may admit a faulty design; few are prone to concede fault in the original stock.

A vivid instance in the writer's memory concerns production heat treating in a commercial plant of trunnions for 105 mm. gun mounts, machined except for final grind, from SAE 4340 forgings, and weighing approximately 23 lb. per piece. More than 2300 such forgings were successfully heat treated to 190,000 p.s.i. minimum tensile strength, on an average of 75 per day, without a single rejection. Suddenly about 23 out of 70 cracked in one day; about 38 out of 75 cracked the next day. Immediate checks on salt baths, pyrometers, oil temperature and viscosity, and operation records, revealed that from the heat-treating aspect all was as it should have been.

Further investigation revealed that the contractor had just previously doubled up on forging suppliers. Cross sectioning of a dozen cracked forgings from the new supplier revealed large bursts, blowholes and pipe at the center of the forgings. Subsequent metallurgical comparison between the forgings of two suppliers immediately proved conclusively that neither the design nor the heat treater were at fault—but that failures were attributable directly to defects inherent in the material itself. Proof as conclusive as this is the only aspirin that will cure a heat treater's headache.

When a heat treater has witnessed failures of one type or another over a long period of years he develops a knack for interpreting the probable causes of cracks that are occasioned—if not actually caused—by heat-treating operations. If cracks develop along lines that are not stress concentration points, likely as not the failure is due not to faulty heat treating but to defects of a chemical or mechanical nature (gas pockets, slag inclusions, seam or laminations, pipes, blow holes, etc.).

It is not our intention to stress too much failures due to innate material defects, but to point out that the mad rush of heavy wartime production does not make for materials as consistently good as normal peacetime manufacturing would insure. It is, however, important to realize that such defects occasionally escape mill inspection; they are never noticed until the *show up* in heat-treating operations. Consequently, by faulty logic they are frequently considered as actually *caused* by some faulty heat-treating technique—which may not necessarily be true.

## Materials Stock Data

Granted that a steel fabricator may buy the highest quality steels manufactured this does not necessarily insure good heat treatment for his products. For midway between fabrication and heat treatment there lies the stock crib and some type of dispatching system—both sources of trouble.

Every stock crib has some more-or-less elaborate system for the identification of stock; it may be segregation by lot or shipment in bins; or by a color code of painting stock. (As a color code for marking metals and alloys the U. S. Bureau of Standards has attempted to standardize the structural steels in Simplified Practice Recommendation R166-37. It naturally does not comprehend the great number of tool steel analysis. See Table 2.)

But mixups do occur in the crib unless superhuman efforts are exerted against them. One rare instance—but true—may be narrated as that of the new stock clerk who classified all bar stock steels according to size alone. But the best *stock* attendant is hampered by the machinist or tool maker who cuts off the identifying marks on stock, thus leaving the remains for possible laboratory analysis.

In any event, this conglomeration of mixups usually finds its outcome in the heat-treating shop, either in the shape of a number of tools supposedly alike in analysis but markedly different in their response to heat treatment; in the form of assemblies where low carbon plate unwittingly is welded to "chrome-moly" tubing; or in the case of production parts machined from an unsegregated accumulation of various SAE or NE steels, merely because the production foreman ran out of one analysis and happened to have the same size in other steels.

In such instances, what is the commercial heat treater supposed to do? These are headaches that stymie his whole productive schedule. They are not mitigated by the dubious compliment of the customer: "Well, you're a heat treater. You figure it out!"

Such mixups in stock can be and have been unscrambled. Chemical analysis is the most reliable, but usually impracticable. Spot reagents may be used if the mixup occurs with known steels. Magnetic inspection is another good method provided equipment is available. Too much faith is put in the spark-test method, sometimes with dire results, due to the complexity of modern alloys and the addition of substitute materials. Consequently, spark-testing is unfeasible especially where analyses are similar but just widely variant enough in heat treatment as to preclude the possibility of one cycle.

Besides, steel identification is not strictly within the sphere of the heat treater's domain. The mistake is not of his making, nor should his reputation depend on his ability to solve another's problem. His task is to produce specified physical properties in a steel of known analysis; the element of the unknown only complicates an already complex problem. Too frequently must the heat treater arrange to transfer full responsibility for the dubious outcome of an important and expensive tool or die that cannot await the results of more complete checking than he can provide.

Next to stock mixups the greatest cause for delay is occasioned by heat-treating orders that provide information that is vague, or none at all. No order for heat treating can be too complete; it should include the material (preferably with a chemical analysis wherever possible); the operation to be performed; the exact physical properties desired, together with the maximum and minimum tolerances; the name of the part or tool, together with its purpose; and any data pertinent to differential hardening, finish required, further machining, etc.

We would stress the importance of information about the job a particular part or tool is called upon to perform—unless, of course, its purpose is obvious—and for this reason: There may be certain tricks and techniques as a result of modern developments which may affect the life and performance of a tool. For this reason both the designer and materials engineer should find it advisable to consult the heat treater as to how best to heat treat a given piece.

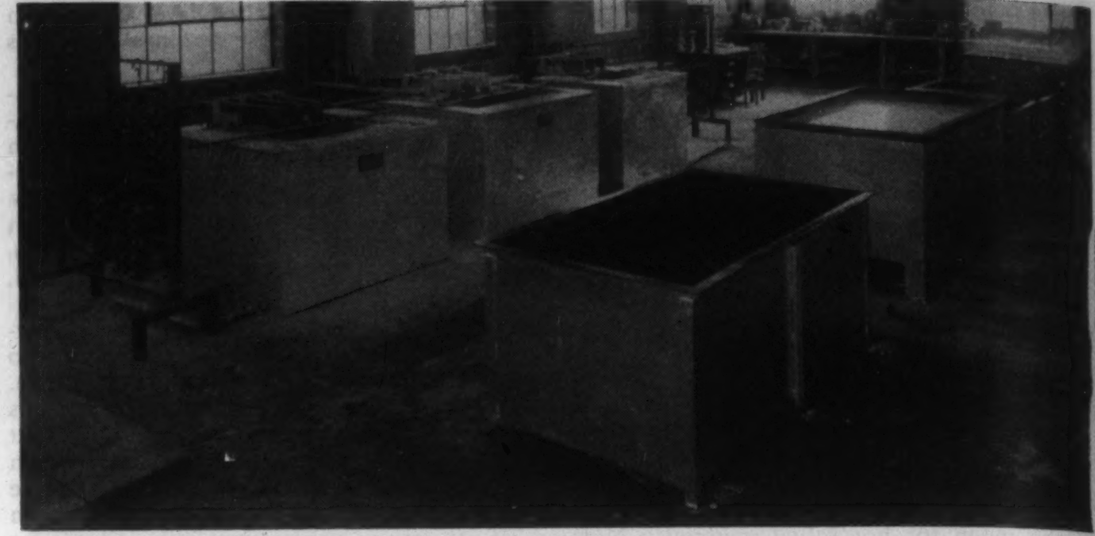


*Fig. 10. Electrode salt baths used for isothermal heat treatment of ammunition parts.*

For advances in heat-treating practices are very rapid, and processes have extended to the point where it is almost impossible for the engineers to keep fully informed on all of them, unless they keep posted from day to day. Some of these new processes, techniques and developments will be discussed briefly later in this Manual.

## Carbon vs. Alloy Steels

Brief mention was made in the beginning of this section about the choice of materials for a given job and the effect of substitute materials on engineering standards. We might amplify this further by a brief discussion of the principles that motivate the selection, by first attempting to dispel some fallacies about materials design. From the standpoint of material conservation and from improved engineering technique, there is a marked trend towards the use of carbon steels; current literature is full of new applications of carbon steels where it was formerly thought only alloys would suffice. On the other hand there is the school of thought that will use nothing but alloy steels, merely because they are alloys. Good engineering takes the middle course, based

*Table 2. Color Codes for Marking Metals and Alloys*

*Steels from Bureau of Standards' Simplified Practice Recommendation R166-37*

| *S.A.E. Number* | *Code Color* |
|---|---|
| | **Carbon Steels** |
| 1010 | White |
| 1015 | do |
| X1015 | do |
| 1020 | Brown |
| X1020 | do |
| 1025 | Red |
| X1025 | do |
| 1030 | Blue |
| 1035 | do |
| 1040 | Green |
| X1040 | do |
| 1045 | Orange |
| X1045 | do |
| 1050 | Bronze |
| 1095 | Aluminum |
| | **Free Cutting Steels** |
| 1112 | Yellow |
| X1112 | do |
| 1120 | Yellow and brown |
| X1314 | Yellow and blue |
| X1315 | Yellow and red |
| X1335 | Yellow and black |
| X1340 | do |
| | **Manganese Steels** |
| T1330 | Orange and green |
| T1335 | do |
| T1340 | do |
| T1345 | Orange and red |
| T1350 | do |
| | **Nickel-Chromium Steels** |
| 3115 | Blue and black |
| 3120 | do |
| | **Ni-Cr Steels (Continued)** |
| 3125 | Pink |
| 3130 | Blue and green |
| 3135 | do |
| 3140 | Blue and white |
| X3140 | do |
| 3145 | do |
| 3150 | Blue and brown |
| 3215 | Blue and purple |
| 3220 | do |
| 3230 | do |
| 3240 | Blue and aluminum |
| 3245 | do |
| 3250 | Blue and bronze |
| 3312 | Orange and black |
| 3325 | do |
| 3335 | Blue and orange |
| 3340 | do |
| 3415 | Blue and pink |
| 3435 | Orange and aluminum |
| 3450 | Black and bronze |
| | **Nickel Steels** |
| 2015 | Red and brown |
| 2115 | Red and bronze |
| 2315 | Red and blue |
| 2320 | do |
| 2330 | Red and white |
| 2335 | do |
| 2340 | Red and green |
| 2345 | do |
| 2350 | Red and aluminum |
| 2515 | Red and black |
| | **Molybdenum Steels** |
| 4130 | Green and white |
| X4130 | Green and bronze |
| | **Mo Steels (Continued)** |
| 4135 | Green and yellow |
| 4140 | Green and brown |
| 4150 | do |
| 4340 | Green and aluminum |
| 4345 | do |
| 4615 | Green and black |
| 4620 | do |
| 4640 | Green and pink |
| 4815 | Green and purple |
| 4820 | do |
| | **Chromium Steels** |
| 5120 | Black |
| 5140 | Black and white |
| 5150 | do |
| 52100 | Black and brown |
| | **Chromium-Vanadium Steels** |
| 6115 | White and brown |
| 6120 | do |
| 6125 | White and aluminum |
| 6130 | White and yellow |
| 6135 | do |
| 6140 | White and bronze |
| 6145 | White and orange |
| 6150 | do |
| 6195 | White and purple |
| | **Tungsten Steels** |
| 71360 | Brown and orange |
| 71660 | Brown and bronze |
| 7260 | Brown and aluminum |
| | **Silicon-Manganese Steels** |
| 9255 | Bronze and aluminum |
| 9260 | do |

on experience and standards, of using that steel that will do the job best.

As an example, occasionally SAE 6150, 4340, or some such alloys are submitted to the heat treater as guide posts, sleeves, shearing punches, or some such part that demands extreme wear resistance, with specified hardness of Rc62 or better. Now such alloys, being of medium carbon content, were not designed for such purposes. Here is an instance where a straight high carbon steel could probably have done a better job; even a low carbon carburized job would have sufficed. Investigation revealed that the alloy steels were specified because it was felt alloy steels would do a better job. Alloy steels will do a better job—provided the proper alloy is used.

Here is another example, in reverse. One customer, dissatisfied with a Rockwell C hardness of 60-62 on a high manganese oil-hardening blanking die (12 in. by 12 in. by 1½ in.) because "it did not wear well under heavy production" made a new one of straight 1.20% C steel. To his consternation the new die distorted badly in a brine quench calculated to get his specified Rc 65. This is an example where carbon steel did not fit the purpose. Greater wear resistance could have been obtained from a variety of high carbon—high chromium alloys—without distortion.

Likewise there is no need to make large forming dies out of high-speed steel (nor gages either) on the supposition that high-speed steel is more wear resistant. High-speed steel is too critical, and a waste of precious material, when a number of chromium or low tungsten alloys would give equally good wear and better shock-resisting properties, or toughness.

Too frequently "wear resistance" is identified with "hardness"; these qualities go hand in hand but they are not necessarily identical. Hardness for what? For wear resistance, for surface finish, for increased tensile strength, for cutting edge at high speeds? Must hardness be sacrificed for toughness and shock-resistance? Or can a happy medium be found in one alloy? Can the piece be hardened with minimum warpage, distortion and volume change? Or are these items strictly secondary? Must the piece withstand constant dynamic stresses? Will it withstand high heats in operation?

These are questions the materials engineer must answer in any adequate choice of tool steel, or of a structural steel converted to a tool steel by surface processes. The heat treater may have no difficulties or headaches in processing anyone of those selected—but he may realize that a wrong choice may result in service failure, with a subconscious feeling that such failures always seem to occur "because the tool wasn't hardened right!"

### Hardenability and Other Factors

The factors that influence the selection of a structural steel are much too numerous to discuss here. They have more to do with stress analysis and design than with materials themselves. But given the specifications required of a part there are certain methods of selection and evaluation that can be used to preclude choices that are arbitrary if not inadequate and wasteful.

We refer to the Jominy hardenability charts and to the various hardening characteristic charts for carbon and alloy steels (see Fig. 6)—which are excellent indications of expected behavior but too often considered as laboratory play-things by those not industrious enough to make use of them. This is especially true where substitution is involved.

In the matter of primary physical properties no great difficulties should be encountered in selecting from a large lot of structural steel suited for a job, provided the element of size, shape, mass, analysis and hardenability are concerned. In the matter of properties considered more-or-less as secondary, these are of no concern to the heat treater. Due to the difficulty of correlating static versus dynamic test results, and because of progress still to be made in testing technique and stress analysis, the actual value of some physical tests is doubtful, if not disputed, and tend more to superstition in the selection of materials than to good, sound, practical engineering. A competent discussion of these factors is presented in "Metallic Materials" by H. W. Gillett (*Steel,* Nov. 1943 to Feb. 1944).

## General Processing and Heat Treatment

Assuming that both the design and the material for a given job are good, there is still another source of possible trouble to the heat treater. Given a piece of steel and a blueprint there may still accrue from the processing departments a number of reasons why heat treating of the piece may necessitate extreme precautions for successful treatment, or, going beyond this, may result in failure of the part by cracking or distortion in treatment, or failure in service shortly thereafter.

### When to Machine?

In the case of structural or engineering steels to be treated to given tensile strengths, usually the first decision to be made is whether to machine the part before or after heat treating. This is a problem to which the heat treater is more or less indifferent. In heat treating an unmachined piece (such as bar stock, plate or forgings), the operator can afford to abandon the kid-gloves attitude in his operations; nor are distortion and volume changes major problems in this instance. These factors are counter-balanced by possible trouble in handling and maneuvering the work and difficulties in inspecting it.

But his major headache can be, and too often is, the complaint that the stock in the heat-treated condition is not machinable. Although the best recommended cycles be adhered to in the process, the heat treater can make no absolute guarantee that a given part will be readily machinable. There are too many variable factors that can influence this condition, some that are characteristic of the metal itself, others that are contingent upon machining practice in vogue at a particular shop.

In turning operations some complain that the stock, e.g. a "chrome-moly" alloy, is not sufficiently annealed to insure easy machining; experimentation may prove that the stock is too soft, that the chip tears. Others readily prefer a stock that has been normalized or heat treated to about 125,000 p.s.i. (Rc 26) with the realization that finely dispersed carbides exert less resistance to the tool edge than the lamellar structure of fully annealed stock.

Such variations in machining practice are exemplified by the fact that one shop will not machine any heat-treated part, while another will perform practically all operations on the same part even if heat treated to Rc 40.

### Machining After Heat Treatment

The advantages of one setup over the other are obvious: Machining after heat treating eliminates rough machining and finish machining, reducing the dual operation to a single one. It necessitates, however, extremely good machining practice, with emphasis upon the necessity of change in rake, clearance and cutting angles, and the advantages of negative rakes in machining hard stock; proper support and stability of setup in the use of the more brittle carbide tools; the use of sleeves or guides to eliminate chatter in extended boring operations; and the imperative use of mechanical as against manual sharpening of drills in drilling operations.

This last feature cannot be overemphasized. One large manufacturer, tooled to perform all machining operations after heat treating forgings, was about to abandon the processing due to the difficulty of the drilling operations. Investigation led to the revelation that drills were being hand ground on a bench grinder.

Experiments were conducted wherein tools were hand ground by (presumably) "experts," ranging from tool engineers to new operators; time-study charts were carefully kept, with the following results: Tools ground by any individual were never consistent in results; tools ground by different individuals were even more inconsistent; mechanically ground drills consistently dwarfed the production capacity of the hand ground tools. Subsequently the bench grinders were removed from the drilling department, all drills were carefully ground on a universal grinder, production exceeded all previous records, and the original setup was maintained. Doubtless, the similar instances of such practice are innumerable.

The advantages of completely machining after heat treating have been somewhat counter-balanced by the recent developments of isothermal heat treatment, wherein a part

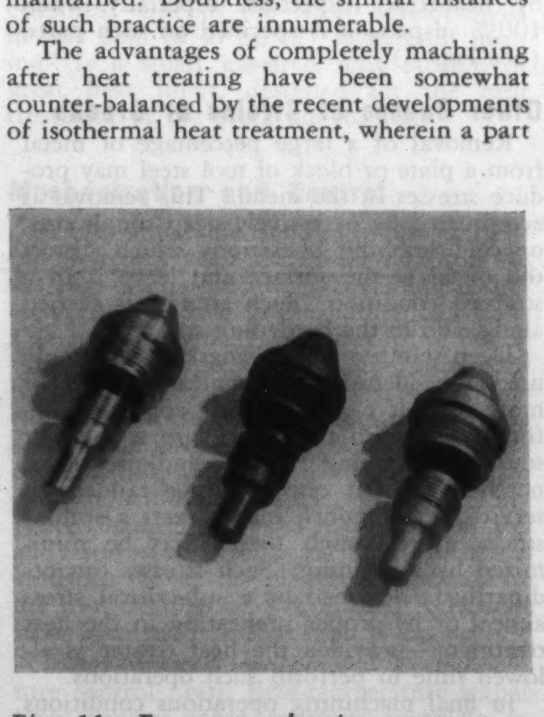


*Fig. 11. Fuse caps showing one as machined, one quenched in nitrate salts, one quenched in bright temper bath.*

may be fully machined even to grinding, and heat treated to specifications with minimum distortion and warpage—provided the stock is sufficiently alloyed and the design of the piece sufficiently uniform to permit this type of treatment. Further aspects of isothermal heat treating will be discussed in another section.

### Machining Before Heat Treatment

In machining a steel prior to heat treatment, the amount of material removed and the method of removing it may have profound effects upon the behavior of the metal in heat treatment. It is necessary to machine off sufficient material from the surface of a piece to guarantee that not only the paint, rust, and mill scale are removed, but also any decarburized material underlying it, so that the maximum hardness may be developed by the quench, especially where wear resistance is of primary importance.

Nor is it sufficient, for example, merely to touch up one side of a hot rolled plate of tool steel on a surface grinder and take a deep cut on the other side. For the variations in cooling rates induced by this practice may tend to cause warpage on the plate, even though the plate is made of non-deforming die steel. Similarly a die plate that is smooth-ground on one side and has rough machine marks on the opposite side may produce in the quench two different cooling rates. The differential may be small, but sufficient to cause distortion in a close-tolerance or delicate die piece. Quenching practice may overcome this difference in cooling rate, but it is better overcome in the machine shop or tool room.

The difficulties of inspecting metal where decarburized material is not removed are repeated here. It is also emphasized that machining a surface solely to present good base metal on which to test unmachined forged or rolled materials would be an invaluable boon to the heat-treating and inspection departments in any shop or plant. Yet this is rarely if ever done by process engineers because of the added expense of another operation. This dubious economy is more than wasted by the hit-and-miss surface preparations that must be undertaken by heat-treat inspectors, especially when 100% inspection is specified on such parts. (See Fig. 7.)

### Other Causes of Strains or Cracks

Removal of a large percentage of metal from a plate or block of tool steel may produce stresses in the metal. This removal is accentuated by excessively deep rough cuts, or cold hobbing operations which distort the metal at the surface and leave it in a strained condition. Such strains, if carried along, add to the hardening strains.

Deep stamp or stencil marks—commonly used for identification marks, instead of more suitable electric etching apparatus, deform and strain the metal, are a constant source of cracking failures, and produce a notch effect that causes fatigue failures in service. Prick punch marks exert a similar strain, even though their effect be minimized by machining. Such stresses can ordinarily be lessened by a sub-critical stress anneal or by proper preheating in the heat treatment—provided the heat treater is allowed time to perform such operations.

In final machining operations conditions may occur over which the heat treater may have no control, but which may be attributed to his failings. Grinding sets up in hardened steel strains that may or may not cause it to crack. Many otherwise good tools or parts are ruined by poor grinding.

Excessive and too rapid removal of material may cause excessive strains and volume changes at the surface resulting in visible grinding checks and the ruin of the tool or part. On the other hand, it is quite easy to hog into the work on roughing cuts, then remove all apparent damage by a fine, smooth, finishing cut—which leaves the tool to fail in short service. Then it is the heat treater's fault, usually; or is it?

Much emphasis has already been placed on the position of holes with relation to one another and in proximity to the side walls of a section. And what was said under the aspect of design applies equally as well in processing, where a certain amount of leeway may be allowed the tool maker or machinist, or where freedom may be granted in the positioning of dowels, bolts, etc.

Aircraft engineers go to great pains to include lightening holes in aircraft assemblies to eliminate all excess weight in concentrating upon the weight vs. strength ratio. Yet the tool design engineer often fails to reap the benefits of using balancing holes or proportioning holes to distribute stress and equalize loading, both in heat treatment of parts and in subsequent operations.

For that reason it is necessary to emphasize the exercise of judgment by the individual tool or die maker with regard to the insertion or balancing holes on large, non-uniform die sections to balance the whole and render the cooling rate more uniform than it would otherwise be. The insertion of such balancing holes—even though not called for on the print—should be a prerogative of the tool maker, especially since failure of the die, either by cracking or distortion, ultimately falls back in his lap for remanufacture. Far from decreasing the strength of the die, judicious dispersal of such balancing factors will aid the distribution of shock and loads in operation.

### Cold Treatment

In finish grinding parts or tools for very close dimensional tolerances, engineers and machinists must be on the lookout for volume changes that may occur long after heat treatment as a result of the aging of the metal. The writer has in mind one particular instance where some two thousand small trunnions for aeroplane machine gun posts were selectively carburized, hardened, and finished ground on a tapered dimension to +0.0002 in. and —0.0000 in. over an average outside diameter of about 1½ in. All parts were accepted by a large aircraft manufacturer by gaging shortly after the grinding operation was finished. Two months later the same parts were rejected for having *shrunk* below the specified dimensional tolerances. Subsequent processing on all future parts included a stabilizing operation at sub-zero temperatures after carburizing and hardening and before final grinding. The volume change was thereby eliminated and the problem licked. This cold treat-

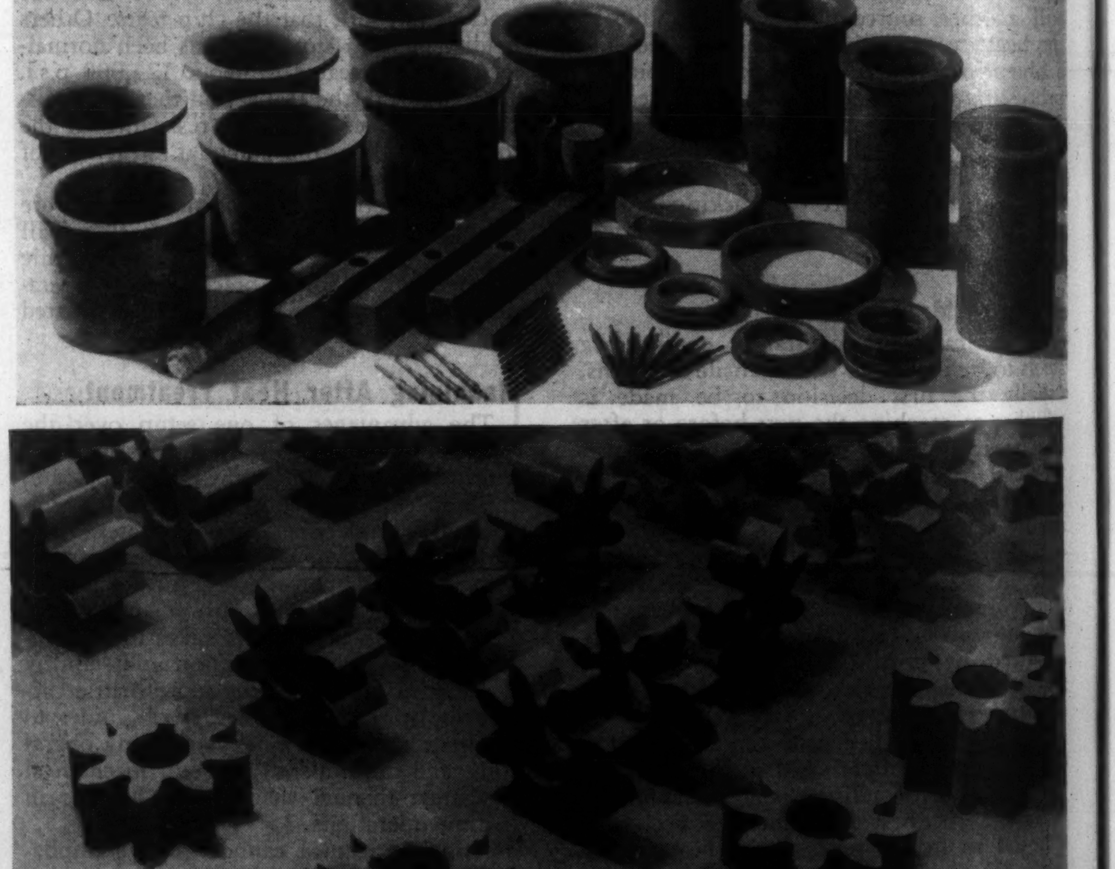


*Fig. 12. Photographs of steels nitrided by speed nitriding method. Upper right and left are stainless steel alloys, 18-8 type. Note clean bright finish after processing. Lower left—bushings, rings, bars and rounds made of Nitralloy G; small spindles are stainless, type 303. Lower right are gears made from Nitralloy N.*

ment is sometimes a necessary concomitant, e.g. in gage and instrument work, where stabilization of the metal is necessary to minimize volume changes. Other aspects of this cold treatment are discussed further on.

### Welding, Brazing, etc.

Occasionally difficulties arise that have to do with heat treating where other applications of heat are involved in prior or subsequent processing, e.g. welding, brazing, soldering, etc. A little forethought would obviate much of the confusion that surrounds such processing but the absence of this thought still continues to cause unnecessary operations. Occasionally an assembly brazed with a low melting copper-base brazing alloy comes to the heat treater for hardening despite the fact that any high temperatures used by him would make short work of the brazing operation. Conversely, parts are sometimes heat treated, finish machined, then welded in a fixture, sometimes with amazing results both from the aspect of weld properties and distortion.

One of the most cogent examples of poor processing and faulty welding is an instance where over two years four large marine gears were submitted to a commercial shop for carburizing and hardening. The gears were urgently needed during the reconstruction at Pearl Harbor, and a plane had been chartered to take them from an East Coast manufacturer. Engineers and expeditors sat on the *heat-treating operations* for two full days. Finally the four gears were removed from the final tempering bath and cooled—only to find all four gears cracked.

Consternation reigned—then recriminations rained—all over the shop. When composures were regained it was noted that all four cracks were similar, the failures occurring not parallel to the gear teeth, but transversely, and at the same height of the taper. Trouble shooting through three large company plants ended 50 miles away—where the hobbing superintendent, not finding stock of suitable diameter for the gears, had welded two slabs of metal together, cut them into blocks and had the gear-teeth machined transverse to the flow of the slabs and the weld. Chemical analysis showed one slab to be low carbon steel, the other a medium carbon alloy steel; oddly enough, the weld deposit revealed a hard-surfacing rod. Consequently, Pearl Harbor had to wait another ten days.

These and other examples would be humorous, were it not for the wasted time, effort and money on products that were not at the time expendable. Processing of any metal part by the engineer is at best a difficult job; it becomes more complex when the operations are multiple; it becomes impossible when he loses sight of the relationship between operations that are mechanical and those that are chemical or physical.

## Progress in Heat Treating Methods and Equipment

Designing technique, choice of materials and specifications for processing result in better heat treatment and better service of tools and parts when all the engineering and production departments concerned are conscious of the variety of methods by which a tool, part or assembly can be processed in the metal treating shop. Apart from the heat-quench-and-draw technique familiar to most engineers, it would be well here to review and comment briefly on some of the more recent developments that have to do with the application of heat, various atmosphere controls, and improved cycles and techniques. Few of them, if any, are actually new; they are all developments based on old principles, mothered and nurtured by the necessity of doing a better and faster job in the wartime speedup.

### Furnaces

In the field of gas fuel technology, the growing trend toward the use of radiant-tube heating elements has resulted in rather spectacular innovations in furnace design. Large assemblies and heavy armor plate sections can be heat treated in controlled atmosphere furnaces, fired by radiant tubes; the furnaces themselves are no longer limited by the practical size of alloy muffles, resulting in units larger in dimensions than were thought possible for this type of operation.

The maximum permissible operating temperature is being constantly increased by the development of high temperature alloys which are expected to render possible the use of gas-fired radiant tubes for temperatures in excess of 2000 F. This same heating principle has found increased use in certain types of immersion heaters in liquids or molten baths, although the extent of use is limited by factors such as temperature limits and chemical reactions. Research being conducted on alloys and coating materials impervious to chemical attack may render more widespread application of immersion heating.

In contrast to the use of radiant tubes just described for heating elements, the same tubes are used in some operations for rapid cooling purposes by blowing a blast of cold air through the tubes under compression. Consequently the use of such equipment lends itself to greater control in heating and cooling cycles, at the same time allowing the use of controlled atmosphere.

Improved design of furnaces and the development of more heat resistant alloy fans and bearing metals have widened the range of application of recirculation type convection furnaces. Formerly limited to temperatures in the tempering ranges of steel, these furnaces now operate to temperatures in the range of 1750 F, thereby lending themselves to hardening, normalizing and annealing operations. This heating principle eliminates the directional effect of radiant heating, thus producing more uniform heating, faster and more adequate distribution, and less distortion. This method has recently found successful application in continuous type furnaces and may eventually find further use in the external firing of molten baths for heat-treating operations, thereby increasing pot life by eliminating the possibility of localized overheating.

Advanced burner design on both gas and oil-fired heating installations has made for more uniform heating and economy of fuel input. While furnace design for gas-fired furnaces has tended more towards the use of a few large burner units rather than a multiplicity of smaller types, the development of radiant cup burners—(wherein combustion is totally internal to the unit itself and heat input takes place by radiation) has found ever increasing use in such units as large externally fired salt bath furnaces, as designed for tempering or stress-relieving steel, or treatment of non-ferrous metals. Its use, however, is not restricted to such low temperature operations, having a variety of applications in many heat-treating operations.

Electricity as a source of heat has long been used in semi-muffle furnaces and in full muffle atmosphere furnaces; it lends itself to constantly increasing application in the immersion units developed for low and medium temperature liquid bath operations, and the popular electrode type furnaces used for salt bath heating operations at any temperature desired. This internal heating method makes for more uniform temperature control, more flexible heat input, more economic pot and salt life, and consequently greater quality production.

### Surface Hardening

Localized application of heat by both gas and electricity finds constantly increasing use in flame hardening and induction heat treating. While these methods, like any others, have limitations both mechanical and metallurgical, they offer leeway to the designer and to the materials engineer. They make possible designing of parts where it is unnecessary to heat the whole piece; hence distortion is reduced if not eliminated; local heating for stress relief can likewise be conducted on finished parts; again, selective hardening can be performed on assemblies welded or brazed prior to heat treating without distortion.

From the material standpoint such methods permit the use of steels of lower alloy and higher carbon content which can be quenched more severely and produce higher hardness and greater available load capacity. Conversely, only shallow hardening alloys should be used, lest the severe quench induce highly stressed surfaces.

Flame-hardening, while not too subject to close control, offers an economy of operation over induction, and also permits more flexibility and accessibility of heat application especially by reason of radical advances recently made in burner design for such purposes. One of the latest developments in this field of so called "furnaceless heating" is a small gas-fired unit capable of great heat input, designed for the heat treatment of bar stock and tubing.

### Mechanization and Control

A very noticeable trend in industrial heating in recent years has been the effort on the part of equipment engineers and manufacturers to reduce to a minimum the variable human element in heat-treating operations, by the introduction of a variety of ingenious furnace mechanisms, both mechanical and electrical. Automatic charging and discharging units; conveyor lines and carriers; fast, automatic quenching mechanisms; synchronized door operations; improved handling devices in the line of jigs and fixtures; all these items have contributed vastly to reduce the manpower shortage in the heat-treating field that might otherwise have been more serious than it has been.

Safety devices incorporated in temperature control units; time-temperature signalling devices; robot controls; complete cycling controls; atmosphere recorders; heat exchange units in various coolants; all these items have made for greater uniformity and reproducibility in heat treatment than could ever have been dreamed of in ordinary peace-time production. Such improvements do not eliminate the human element; they merely relieve some of the physical burden of the work, emphasizing the need of skill and intelligence in the care, maintenance and operation of equipment calculated to perform a job that rates higher in quality and quantity of production.

### Controlled Atmospheres

The antiquated methods of atmosphere control and surface protection of metals by means of packing in inert or slightly reducing solid materials has long since given way to the more flexible applications of gases and molten salts that may be neutral, oxidizing or reducing—depending on the results desired. Gas carburizing was successfully used long before the war, but new atmospheres have been produced to permit more accurate control of case depth and carbon concentration. Carburizing salts effect the same results and offer greater operating flexibility, especially on continuous production of small parts, and in cases where transfer quenching or martempering operations are desired.

Much excellent work has been done recently with gas atmospheres on surfaces that were decarburized in the steel mill or the forge shop. It has been found possible to restore completely the sub-standard carbon content of a weakened surface layer. Research has shown that in many applications, the low strength of the decarburized surface is the controlling factor in the performance of a part.

For this reason the engineer usually predicates his design on experience with similar parts, and where fatigue stresses or heavy loading are requisites, the parts so designed may be considerably in excess of the theoretical physical requirements. The effects of carburization on the surface of a heat-treated material are serious, in the light of performance under dynamic stress.

Now it has been found possible to restore the carbon content of the surface by heating in contact with a gaseous atmosphere in equilibrium with the carbon content of the base metal. This so called "skin recovery" —or better "facial uplift"—is used on springs and such highly stressed parts to increase fatigue resistance, which might otherwise be accomplished only by surface machining or by shot-peening with subsequent working stresses.

The neutral atmospheres have long been used for hardening, annealing, spheroidizing, normalizing and such operations performed above the scaling point of iron-carbon alloys. They find a fertile, almost virgin, field in the forge shop and the steel mill, where the ultimate acceptance or rejection of controlled atmosphere for reheating purposes will depend on economy and practicability. Under many dynamic stresses the strength of the surface is frequently the strength of the part, and one can scarcely estimate the money expended on heat-treated alloy steels where the performance criterion ultimately lay in the low strength of an outer surface rather than on that of a heavy base metal.

Another innovation in atmosphere control has to do with bright gas quenching developed for the heat treatment of aircraft tubing and now finding application on similar parts and assemblies. Jets of cold, compressed, deoxidized gas are directed upon the work in a chamber, and cooling rates are obtained on thin sections that were thought impossible save by liquid quenching.

Another reducing type of reaction is accomplished in gas pickling operations wherein strip steel is treated at red heat in a furnace containing anhydrous hydrogen chloride and a minimum amount of water vapor. In fact gases have been developed for virtually every type of reaction with metals, both ferrous and nonferrous.

### Salt Bath Treatment

Virtually everything previously stated about gaseous atmospheres pertains more or less to salts and salt bath treatment. The increasing use of liquid baths owes its rise to these distinct advantages: Greater uniformity of temperature control; more uniform heating between unequal sections; a protective film from bath to quench; faster heat input and increased production; minimum distortion and warpage; simpler atmosphere control from the standpoint of equipment and operation.

Neutral salts in a variety of analyses from 300 to 2400 F have been in common use for years. Liquid carburizing baths, containing varying amounts of cyanide content and utilizing several energizers for given case depths, have also taken their place beside the solid and gas carburizing processes on a heavy production basis. More recent advances in this field have been the development of a variety of tempering salts and quenching salts (as in so-called isothermal treatments) that are of a reducing nature and impart a bright metallic finish or a silver finish to the surface of work treated therein, thus eliminating the cleaning and pickling of finished work after heat treatment; this allows finishing of parts to finished dimensional tolerances without danger of surface changes.

The combination of transforming electric energy to heat energy and the rapid strides towards perfecting salt bath analyses has resulted in one of the greatest boons to wartime production: The immersed electrode salt bath furnace for the heat treatment of high speed steels. High speed heat treatment is one of the most exacting required, and for several reasons: The temperatures required (especially on the tungsten and cobalt types) approach the melting point of the steels; the high heats used, plus the tendency of the molybdenum and cobalt types to decarburize and scale, makes atmosphere control imperative in most instances; if carbonaceous materials are used for an atmosphere or for protection against oxidation, the danger of fusion is frequently encountered; when the rate of heating for the high temperatures is slow, grain growth is inevitable; if the steel is air cooled, oxidation results, and if oil quenched, distortion is sometimes involved.

All these difficulties are lessened, if not entirely eliminated, by the salt bath process, and in equipment such as is shown in Fig. 8. This setup consists of three furnaces, a preheat, a high heat and a quench; a double preheat is sometimes used, especially on heavy production hardening; the high heat furnace is an immersed electrode with ceramic pot; the preheat and quench furnace are gas-fired.

The neutral salt baths used in the process prevent both carburization and decarburization. The preheat and quench baths aid in reducing fixed volume changes and distortion to a minimum. The uniformity of the bath under close temperature control eliminates pitting and fusion and the rapid heat input in the electrode furnace prevents grain growth. With proper care of the salts and adequate temperature control, the salt bath method of heat treating high-speed steels of all types is being successfully carried out on a large scale all over the country today.

### Nitriding with the Aid of Salts

Tool life of high-speed steels—whether hardened in salt baths, atmosphere control, or by whatever method—can be greatly increased by immersing the finished ground tool in a high speed casing salt long enough to absorb a shallow superficial nitrided case of extreme hardness. The function of this shallow glass-hard surface is to increase resistance to friction; to reduce the galling, grabbing, or welding effect of the chip; to prevent a harder surface to chip abrasion, thereby reducing the "crater effect" produced by chip removal directly behind the cutting edge of the tool that ultimately causes spalling of the fine edge.

This operation, performed after the tool is ground to size, is conducted at temperatures usually in the same range as those used for tempering high-speed steel. The depth of case produced (usually from

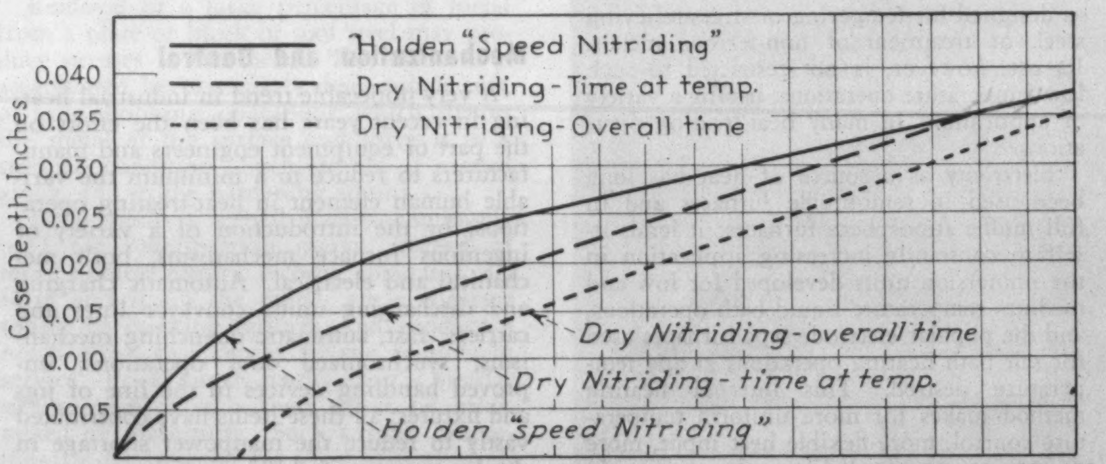


*Fig. 13. Ratio of time vs. case depth of two methods of nitriding. Nitralloy No. 135, modified. Operating temperatures 975 to 1000 F.*

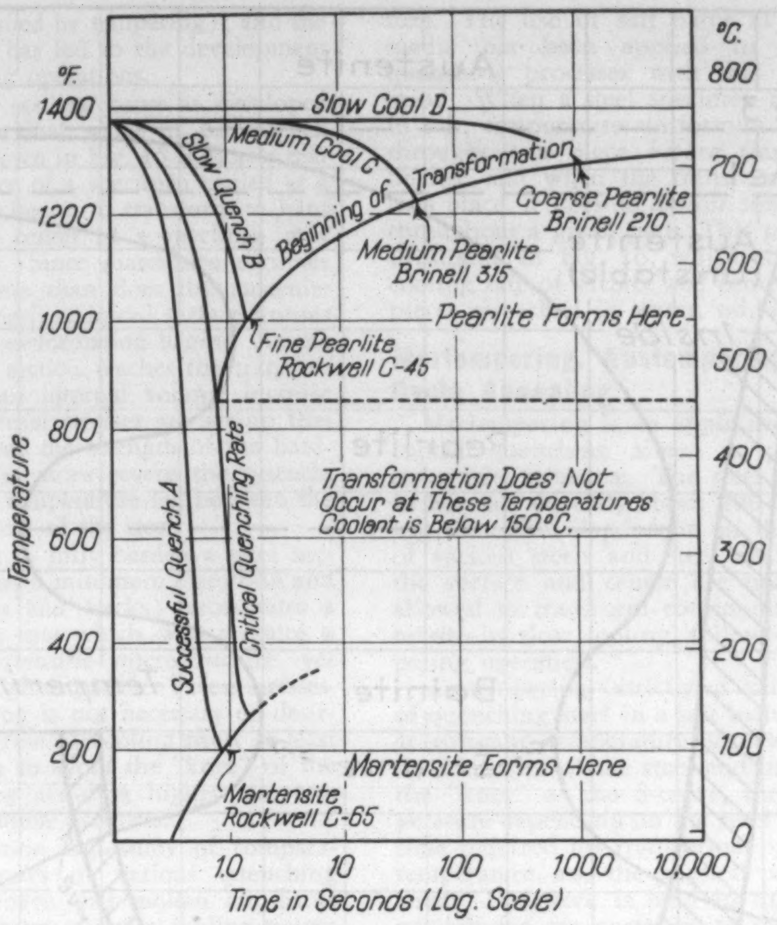


*Fig. 14. Schematic representation of the relation between cooling rate and temperature of initial transformation on cooling (Bain).*

0.0005 to 0.001 in.) is usually not sufficient to embrittle the tool. The coefficient of friction can sometimes be further reduced in many cutting operations by a double operation: (1) Nitriding the tool; (2) immersing the tool in a sodium and potassium nitrate bath at 950 F, or in an aqueous solution of sodium hydroxide and sodium nitrite at about 290 F, for 15 to 20 min.; the purpose of the secondary operation being the formation of a thin layer of black iron oxide to act as a lubricant. (The success of this treatment is brought out in a typical production report in Table 3.)

The latest development in the field of liquid heat treatment (and one too often confused with the casing process just described), is the application of salts as a heating medium and catalyzing agent to nitriding operations by the "Speed Nitriding" process developed by the author's company, and applicable to standard Nitralloy grades, stainless steels, and certain alloy structural steels (with reservations depending on alloying elements that have an affinity for forming nitrides). Regular Nitralloy grades of steel are nitrided, by dissociating ammonia through a molten salt bath in which the work is immersed, with hardness values at least as good as those obtained by the conventional dry method, one major feature being the distinct time saving advantage. The necessity of packing and sealing in retorts, with its necessary labor; preheating and slow cooling operations—these items are eliminated without sacrificing straightness; and the actual nitriding cycle is speeded up by the use of catalytic agents. A variety of parts are being commercially processed in this fashion at from one-half to one-third the time consumed by the conventional method.

Results obtained thus far on the nitriding of stainless steels indicate that the process is much more satisfactory than the regular dry methods in use. Hardness results obtained on austenitic and straight chromium types are comparable with those obtained on standard Nitralloy grades; but the case depths obtained are not nearly so deep, being limited to about 0.010 in. for practical commercial purposes.

Corrosion tests indicate that there is some sacrifice of resistance, e.g. a 303 type stainless would have about the same corrosion resistance after nitriding as a 416 type has before nitriding. Since corrosion resistance is at best a relative term, the available data on the non-corrosive properties of nitrided stainless must be interpreted on the basis of particular applications.

Medium and low alloy steels of the "chrome-moly" types have also been nitrided, but due to the lower alloying content surface hardnesses are not so high as those obtained on Nitralloy and stainless, but are sufficiently high to increase wear resistance and fatigue values. Other advantages offered by the "Speed Nitriding" process are these: Consumption of ammonia is more economical, being in the order of one-fourth to one-fifth that consumed by the conventional dry method. Since growth and distortion are functions of time at temperature and uniformity of temperature, respectively, these two items are considerably reduced. Selective nitriding can also be conducted. The temperatures used in the process are essentially the same as for regular nitriding cycles, that is, they are sub-critical and do not involve quenching procedures.

## Cold Treatment

Paradoxically enough, closely allied with the heat treatment of metals are the newer developments in the cold treatment of metals, mentioned earlier. Sub-zero refrigeration with temperatures as low as -120 F has long been used for the storage of duralumin alloys to retard the precipitation hardening after solution heat treatment; in the stabilization and artificial aging of tools, gages, and precision parts to prevent dimensional changes in close tolerances; and in chilling metals for shrink fit assembly work. One of the latest claims for this method is the permanent expansion of iron-based

*Table 3.—Plant Production Report*
*Before and After Results of High-Speed Casing*

| *Description of Tool* | *Material Machined* | *Temperature of Bath* | *Time In Bath (min.)* | *Production* | | *% Net Gain* |
|---|---|---|---|---|---|---|
| | | | | *Before HSC* | *After HSC* | |
| Key way cutters, 1/8 in. thick, 1/2 in. overall width | SAE 4140 Steel H. T.*, Rockwell 40 C | 1040 F. | 20 | 20 | 60 | 200 |
| Taps 10-32 | SAE 4140 Steel H. T., Rockwell 38 C | 1040 F. | 15 | 25 | 180 | 620 |
| Milling saws, 1/16 in. thick, 6 in. overall | Copper | 1004 F. | 20 | 180 | 440 | 144 |
| Taps 6-40, (drills for above taps) | Silicon steel laminations | 1040 F. | 12 | 275 | 3500 | 1172 |
| Thread mill | SAE 4140, Steel H. T. | 1040 F. | 20 | 10 | 37 | 270 |
| Drills, 1/8 in. dia. | SAE 4140, H. T. Rockwell 29 C | 1040 F. | 20 | 600 | 1200 | 100 |
| | | | | Average Net Gain | | 377 |

* *H.T. Heat treated.*

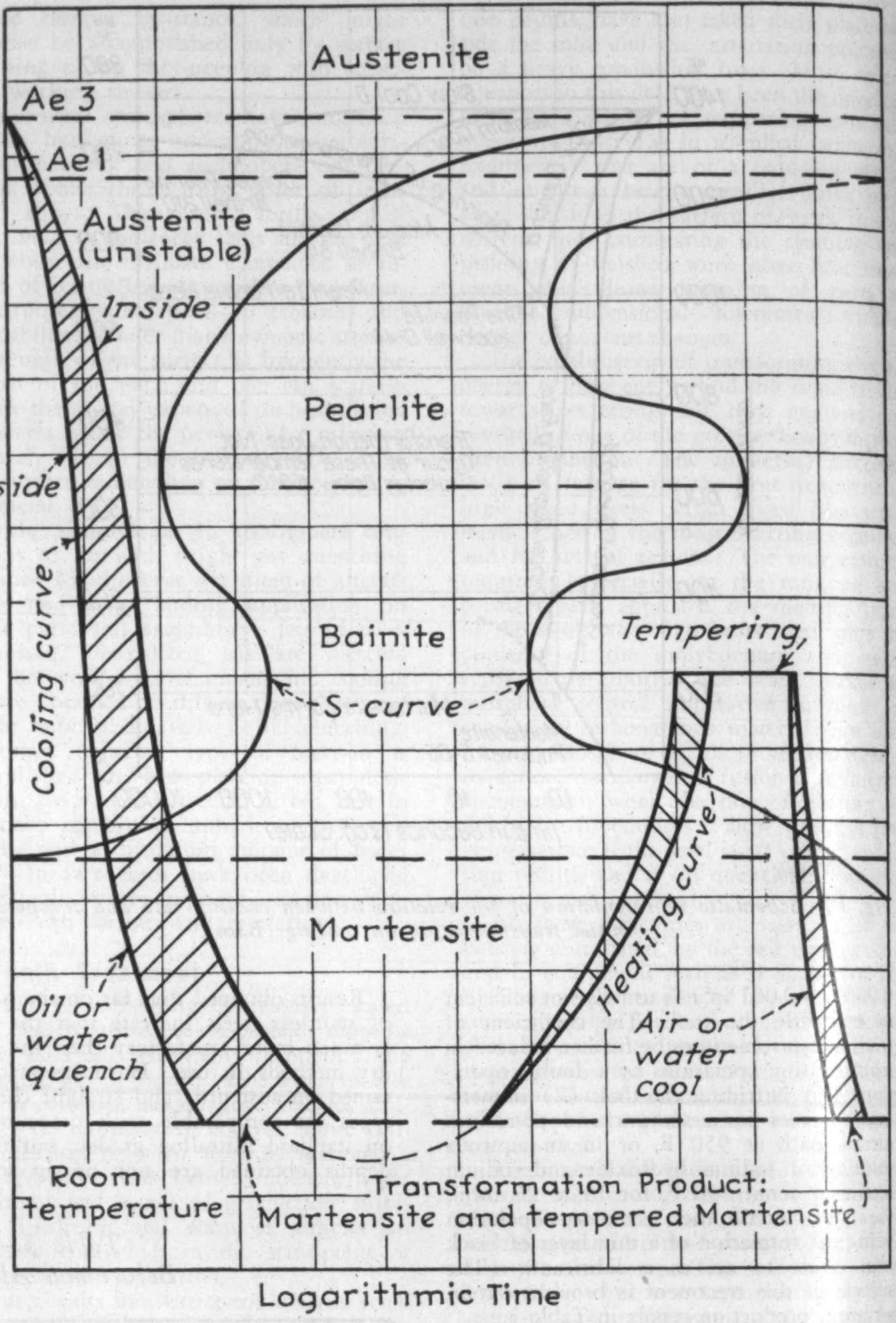


*Fig. 15. Conventional quench and temper process: Cooling curve and its relationship to a typical TTT curve.*

alloys by subjecting parts to temperatures 300 deg. below 0 F.

More recently sub-zero refrigeration has been applied in a variety of methods to high speed steels, high carbon steels, non-deforming die steels, high carbon-high chromium bearing steels, and nickel carburizing steels. This low temperature cooling, usually conducted as low as −120 F, both in continuous and interrupted cooling cycles, materially aids in the transformation from austenite to a nearly complete martensite structure.

This, it is claimed, results in more uniform structure, increased hardness, greater wear resistance, and longer tool life. Tests indicate that impact values and ductile qualities are improved when this increased hardness is retempered to standard values. Other results claim increased magnetic properties for steels subjected to such low temperatures.

Some dispute the merits claimed for the process, arguing that the refrigeration does not accomplish anything that can not be done by proper heat treatment, but being more or less forced to the admission that cold treatment is at least good insurance against the possibility of inadequate heat treatment. Others argue for the retention of some austenite for the sake of ductility, but present evidence indicates that the retained austenite in a tool steel does not impart the same ductile qualities as the same structure in an austenitic steel.

The matter is controversial, but it has stimulated much research towards increasing tool life and production. It may be that a whole new field is opening in the field of metal treating, and, oddly enough, we seem to be approaching the day when the heat treater may be called the cold treater.

### Interrupted Quenching

Perhaps the greatest strides taken in the field of heat treatment of steel in the past five years have been the practical exploitation and commercial application of S-curves or time-temperature-transformation (TTT) curves to wartime production. It is difficult to class the variety of heat-treating operations that have evolved from these curves under one comprehensive title, unless it be termed "Interrupted Quenching"; the operations include austempering, isothermal quenching, martempering, and cycle annealing.

It is not the purpose of this Manual to go into detail in the discussion of transformation at constant temperatures and on continuous cooling, but merely to discuss the significance of this new trend in heat treating, to differentiate the mechanics of each operation by means of diagrams, and to discuss the possibilities of these methods in the light of design, materials and processing. Detailed articles on the work of Bain and Davenport, Greninger and Troiano, Grange and Kiefer, Payson and Klein, Cohen, Shepherd and others are listed in the appended bibliography.

Of all the operations under "Interrupted Quenching," none of them are really new, having been practiced many years in one form or another; but it has only been within the last 15 years that the underlying metallurgical principles were developed and the reasons of behavior under certain treatments completely understood. It took the war to make these operations commercially feasible.

Experimentation on the transformation of austenite to its end products has revealed that when cooled continuously below the minimum temperature of its stability, austenite does not transform immediately; when cooled very slowly transformation proceeds substantially at equilibrium temperatures; faster cooling lowers progressively the temperature where transformation begins and it then proceeds over a range of temperatures.

Thus, for a given steel, the cooling rate determines the temperature range and the time over which the transformation takes place and the physical properties of the end structure. Time-temperature-transformation curves have been developed for most common grades of steel, based on investigation of constant temperature (or isothermal) transformation.

Since commercial practice naturally does not lend itself to isothermal transformation in every instance as determined by small specimens of fixed size, the next logical step was to correlate the relationship between transformation at constant temperatures and transformation at continuous cooling rates. Fig. 14 represents, schematically, the cooling rate against temperature of transformation on cooling for an 0.85% C steel.

Correlation of data on transformation from austenite at constant temperature and on continuous cooling at given rates have proven three major points: (1) that austenite can be transformed isothermally to pearlitic structures at high temperatures; (2) that austenite can be transformed isothermally to harder, tougher, bainite structures at medium temperatures; (3) that austenite can be transformed to hard, martensite products at lower temperatures, not isothermally, only by continuous cooling.

Application of this first major point has led to the introduction of controlled cycle annealing; the second point has opened the field of austempering (strictly so called) and isothermal quenching (actually austempering modified by tempering); and the third principle has led to the development of martempering operations.

Study of the cooling curve as developed for the conventional water or oil quench procedure as shown in Fig. 15 indicates that when the surface of a specimen cooled at a critical rate has begun to transform to hard martensite, the center of a specimen may lag far behind. Since martensite occupies a greater volume than does the austenite from which it derives, initial surface stresses are set up as transformation begins. As the interior of the section reaches the transformation range an internal volume increase occurs and internal stresses are set up that sometimes exceed the strength of the hardened shell. The more severe the quench, the greater the temperature lag between the surface and center of the steel.

Any attempt to fully harden a steel successfully (i.e., with minimum distortion and without stresses and cracks) necessitates a critical cooling rate which will produce a completely martensitic microstructure, yet not severe enough to produce excess stresses. If full hardening is not necessary or desirable, then the rate of cooling must at least be fast enough to avoid the "knee" of the S-curve, thereby avoiding higher temperature transformation products.

Experimentation and study of comparative cooling rates of various quenching media have proven that molten salt baths above 400 F have as great cooling power as mineral quenching oils at room temperature. The use of salt baths as quenching media has been applied to interrupted quenching processes with this purpose in mind: When a steel specimen is quenched in salt, temperature uniformity is obtained throughout a piece *before* transformation begins; and when the transformation does take place, it does so *almost simultaneously* throughout a given part. This point is well illustrated in Fig. 16, which compares the cooling rate of surface and center of similar pieces quenched in water, oil, salt and air.

### Martempering, Austempering and Cycle Annealing

Martempering is an application of interrupted quenching aimed at producing a martensite structure. The steel is quenched in hot salt (usually about 400 F, but varying somewhat dependent on the Ms point of various steels and steel analyses) until the surface and center are uniform, then allowed to transform continuously to martensite by slow cooling, followed by a tempering operation.

Austempering (strictly so called) consists of quenching steel in a salt bath maintained at constant temperature somewhere above the Ms point of the steel and usually below the "knee" of the S-curve, the exact temperature depending on the steel analysis, the time required for transformation at a given temperature, and the physical properties desired. The work is held in the bath long enough for the austenite to transform isothermally into bainite, an intermediate structure between martensite and pearlite structures.

Isothermal quenching (also called "transfer quenching," "flow heat treatment," etc.) is a modification of the austempering operation, wherein the bainite product reached at the end of transformation is transferred to a second salt bath at a higher temperature for tempering, in order to reduce the tensile strength and allied properties. (See METALS AND ALLOYS, October, 1944, pp. 967 and 968 for a schematic representation of these operations based on TTT curves.)

Production records on a variety of steels processed by any of the above three methods indicate conclusively that non-uniform volume changes are reduced, high stresses are prevented, warpage and distortion are at a minimum, and the physical properties obtained are generally better than those obtained by the conventional heat-quench-and-draw method. These operations are not a panacea for all heat-treating evils; the materials engineer is necessarily restricted to the use of a deeper hardening steel and the designer is sometimes confined by sectional sizes and uniformity of dimensions. But on the other hand the designer can assume that minimum internal stresses are set up by this type of processing and can estimate on greater useful strength per given area, while the process engineer can grind highly loaded surfaces prior to heat treatment, thus insuring a better product.

Constant temperature transformation has been applied to processing for high tem-

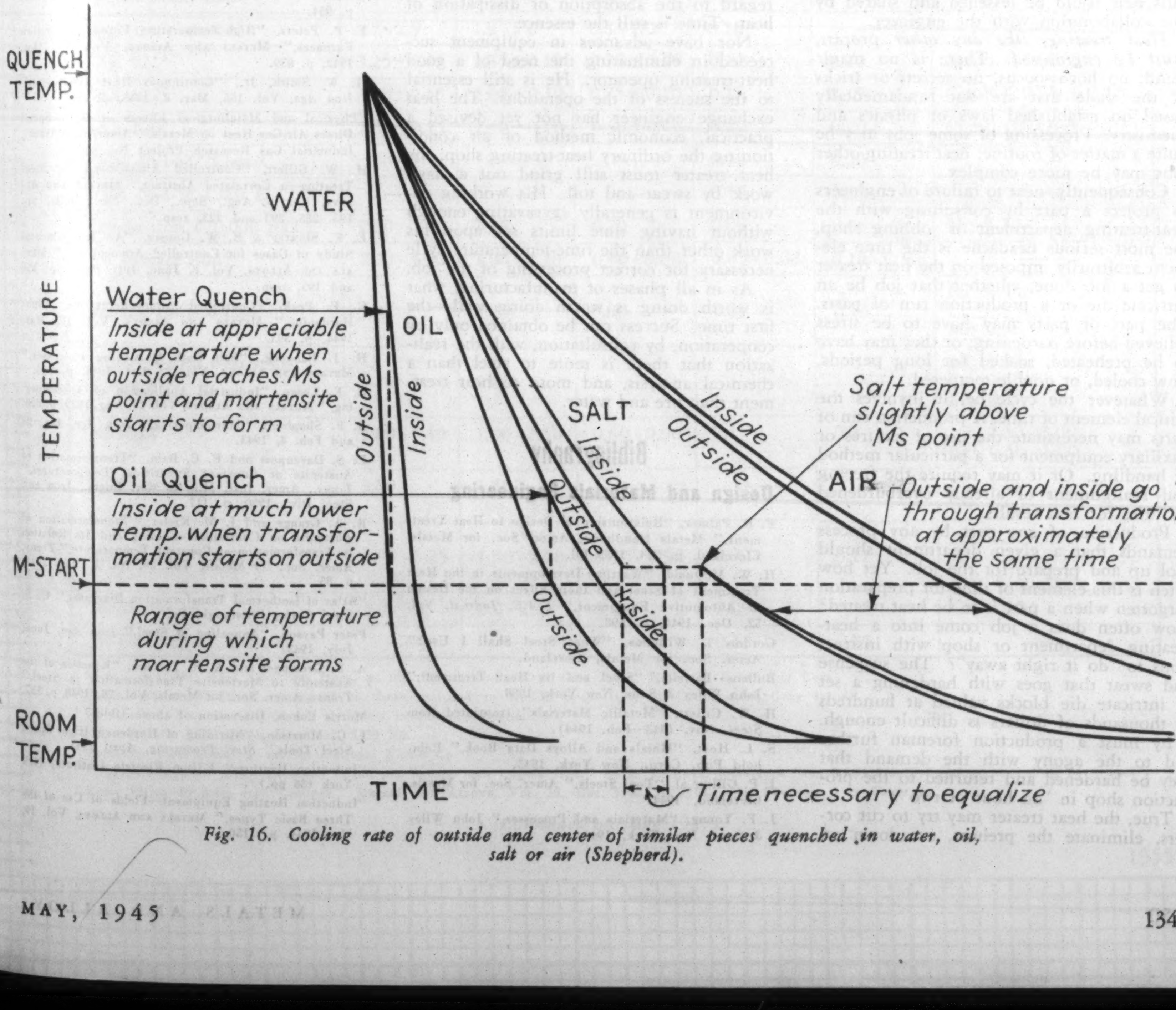


*Fig. 16. Cooling rate of outside and center of similar pieces quenched in water, oil, salt or air (Shepherd).*

perature products (pearlitic and spheroidized structures) under the name of cycle annealing. As schematically represented in figure 30, the operation consists of heating the steel just above the equilibrium temperature and cooling by quenching into a hot medium below the equilibrium temperature, but well above the nose or knee of the S-curve, the exact temperature depending on the type of pearlitic structure desired. If the steel is held at the selected temperature long enough to allow complete isothermal transformation, cooling to room temperature may be conducted in air or water without further microstructural changes. An alternate is to allow for partial transformation at constant temperature, followed by air cooling, dependent upon properties desired.

The function of short cycle annealing is not so much to prevent non-uniform volume changes, warpage, distortion, etc.,—since cooling rates in annealing cycles usually prevent these phenomena—but to aid the heat treater in better controlling and reproducing structures normally obtained by slow cooling cycles. Aside from better control and reproducibility, the long drawn out cycles established for full annealing and spheroidizing operations have been reduced to a mere fraction of the time formerly required. In addition to carbon and low alloy types, high-speed steels, the air hardening types and such analyses as are sluggish to reach equilibrium and hence difficult to anneal, have all been successfully reduced to pearlitic structures in relatively short time cycles.

This rapid method of softening steel and producing more machinable structures should be a big boon in promoting the use of more highly alloyed steels, previously avoided wherever possible because of machining difficulties. Thus a combination of isothermal treatments would insure better alloys and greater machinability, followed by better heat treatment, less internal and external stresses,—and consequently greater design possibilities.

## Conclusion: The Personal Equation

Up to this point we have discussed the relationship that design, materials and processing have to do with heat treatment, together with some of the newer equipment and techniques that affect this relationship. There remains one other approach that might also simplify and better the relationship between the heat treater and the engineer, namely, that of the human element, the personal equation.

Headaches are caused and suffered in the heat-treating business primarily because the heat treater is more or less human and presumably has a head susceptible to aches and pains, worries and fears. Much of the mental burden and responsibility to which he falls heir could be lessened and shared by due collaboration with the engineer.

*Heat treating, like any other process, must be engineered.* There is no magic wand, no hocus-pocus, no secrets or tricks of the trade that are not fundamentally based on established laws of physics and chemistry. Processing of some jobs may be quite a matter of routine; heat treating other jobs may be more complex.

Consequently, next to failure of engineers to project a part by consulting with the heat-treating department or jobbing shop, the most serious headache is the time element arbitrarily imposed on the heat treater to get a job done, whether that job be an intricate die or a production run of parts. The part or parts may have to be stress relieved before hardening; or they may have to be preheated, soaked for long periods, slow cooled, or double tempered.

Whatever the cycle be, it involves the critical element of time. A production run of parts may necessitate the use of fixtures or auxiliary equipment for a particular method of handling. Or it may require the freeing and realignment of already overburdened facilities for best results.

Production of any part by any process demands that a given department should tool up and prepare for the job. Yet how often is this element of time for preparation forgotten when a part is to be heat treated? How often does a job come into a heat-treating department or shop with instructions to "do it right away"? The suspense and sweat that goes with hardening a set of intricate die blocks valued at hundreds or thousands of dollars is difficult enough. Why must a production foreman further add to the agony with the demand that they be hardened and returned to the production shop in "an hour or two"?

True, the heat treater may try to cut corners, eliminate the preheat, cut down on the tempering time—but if he does, he is a bigger fool for attempting to abide by instructions of one who, perhaps, would reconsider if he realized what his demands involved. It is better to have a valuable part returned right—two hours late!—than have it go back at the specified time in pieces, or warped, or ready to fall apart in use.

The last decade has witnessed many wonderful advances and improvements in design and equipment and the development of technique and processes in heat treating. But it has not produced any marked improvement in changing the nature or behavior of steel or any other metal with regard to the absorption or dissipation of heat. Time is still the essence.

Nor have advances in equipment succeeded in eliminating the need of a good heat-treating operator. He is still essential to the success of the operations. The heat exchange engineer has not yet devised a practical, economic method of air conditioning the ordinary heat-treating shop; the heat treater must still grind out a day's work by sweat and toil. His working environment is generally aggravating enough without having time limits set upon his work other than the time-temperature cycle necessary for correct processing of the job.

As in all phases of manufacturing, what is worth doing is worth doing well—the first time. Success can be obtained only by cooperation, by consultation, with the realization that there is more to steel than a chemical analysis, and more to heat treatment than fire and water.

## Bibliography

### Design and Materials Engineering

F. R. Palmer, "Relationship of Design to Heat Treatment," Metals Handbook, Amer. Soc. for Metals, Cleveland, p. 214, 1939 Ed.

H. W. McQuaid, "Wartime Developments in the Heat Treatment of Steel and their Effect on the Design of Automotive Equipment," *S.A.E. Journal*, Vol. 52, Dec. 1944, p. 598.

Gordon T. Williams, "What Steel Shall I Use?" Amer. Soc. for Metals, Cleveland.

Bullens—Battelle, "Steel and its Heat Treatment," John Wiley & Sons, New York, 1938.

H. W. Gillett, "Metallic Materials" (reprinted from *Steel*, Nov. 1943—Feb. 1944).

S. L. Hoyt, "Metals and Alloys Data Book," Reinhold Pub. Corp., New York, 1943.

J. P. Gill et al, "Tool Steels," Amer. Soc. for Metals, Cleveland, 1944.

J. F. Young, "Materials and Processes," John Wiley & Sons, New York, 1944.

"Machining of Metals"—Symposium at National Metal Congress—Amer. Soc. for Metals, Cleveland, 1938.

H. B. Pulsifer, "Inspection of Metals," Amer. Soc. for Metals, Cleveland, 1941.

### Heat Treating Methods and Processes

L. E. Biemiller, "Use of Gas in Processing the Materials of Tomorrow"—Paper at 1944 War Conference on Industrial and Commercial Gas, Rochester, N. Y.

W. Lehrer, "Gas Quenching," *Steel*, Apr. 10, 1944, p. 98.

J. J. Turin, "Gas Pickling of Steel," *Iron Age*, Apr. 20, 1944.

Carroll Cone, "New Horizons for Industrial Gas," *A. G. A. Monthly*, April 1944, p. 155.

O. C. Cullen, "Skin Recovery for Decarburized Steel Surfaces," METALS AND ALLOYS, Vol. 20, Oct. 1944, p. 954.

F. P. Peters, "High-Temperature Forced-Convection Furnaces," METALS AND ALLOYS, Vol. 16, Oct. 1942, p. 639.

H. W. Smith, Jr., "Continuous Heat Treatment," *Iron Age*, Vol. 155, Mar. 8, 1945, p. 58.

"Physical and Metallurgical Effects of High Speed Direct Air-Gas Heat on Metals," Amer. Gas Assoc., Industrial Gas Research Project No. 48.

H. W. Gillett, "Controlled Atmospheres in Steel Treating—a Correlated Abstract," METALS AND ALLOYS, Vol. 6, Aug., Sept., Oct., Nov., 1935, pp. 195, 235, 293 and 323, resp.

E. E. Slowter & B. W. Gonser, "An Experimental Study of Gases for Controlled Atmospheres," METALS AND ALLOYS, Vol. 8, June, July 1937, pp. 159 and 195, resp.

C. E. Peck, "Controlled Atmospheres for Bright Hardening," METALS AND ALLOYS, Vol. 19, Mar. 1944, p. 593.

H. J. Babcock, "Salt Bath Quenching Processes," METALS AND ALLOYS, Vol. 20, Oct. 1944, p. 964.

E. E. Legge, "Industrial Application of Austempering," METALS AND ALLOYS, Vol. 10, Aug. 1939, p. 228.

B. F. Shepherd, "Martempering," *Iron Age*, Jan. 28 and Feb. 4, 1943.

E. S. Davenport and E. C. Bain, "Transformation of Austenite at Constant Subcritical Temperatures," *Trans.*, Amer. Inst. Min. & Met. Engrs., Iron and Steel Div., 1930, p. 117.

R. A. Grange and J. M. Kiefer, "Transformation of Austenite on Continuous Cooling and Its Relation to Transformation at Constant Temperature," *Trans.* Amer. Soc. for Metals, Vol. 29, No. 1, Mar. 1941, p. 85.

"Atlas of Isothermal Transformation Diagrams," U. S. Steel Corp., Pittsburgh, Pa.

Peter Payson, "Annealing of Steel," *Iron Age*, June, July, 1943.

A. B. Greninger and A. R. Troiano, "Kinetics of the Austenite to Martensite Transformation in Steel," *Trans.*, Amer. Soc. for Metals, Vol. 28, 1940, p. 537.

Morris Cohen, Discussion of above (ibid.)

J. G. Morrison, "Nitriding of Hardened High Speed Steel Tools," *Steel Processing*, April 1944.

"Induction Heating," Edison Electric Institute, New York (36 pp.)

"Induction Heating Equipment—Fields of Use of the Three Basic Types," METALS AND ALLOYS, Vol. 19, May 1944, p. 1150.

METALS and ALLOYS
Engineering File Facts

NUMBER 80
May, 1945

# High Strength Cast Irons

**What Are High Strength Irons?**

The term "high strength cast iron" is applied to those irons that are gray and machinable as cast and that have tensile strengths of 40,000 p.s.i. or greater. Some of these contain no alloying agents; others have up to 3% alloy content. Of course, there may be other irons having strength properties in this range: Corrosion resistant irons (highly alloyed and sometimes not economically machinable) and wear resistant irons (alloyed, heat treated or chilled cast irons likewise not generally machinable and not gray irons), but these are not properly classed with the engineering materials known as high strength or high test cast irons. Some of the properties and characteristics of these materials are listed in Tables 1 and 2.

**Foundry Practice**

The three common furnace types used for the making of high strength gray irons are cupola, air and electric furnaces. Cupola iron is the cheapest and easiest to make; the air and electric furnace products can be more closely controlled, and much of the alloy iron is made in one of these types. The pouring and molding practices are the same as for regular gray iron.

Because of the necessity for closer control of the melting phase of high strength cast iron production (and the strict metallurgical control of the pouring as well as the melting phase) these irons are more expensive than the ordinary gray cast irons. There are two common types of high strength irons:

(1) Alloy high strength irons in which alloying agents are used to retard graphitization. These agents lower the temperature of austenite decomposition upon cooling sufficiently so that the resulting pearlite is very fine, and the finer the pearlite lamellae the greater the hardness and strength of the casting. The more common alloys used in this type of cast iron are

*Table 1.—Compositions of Typical High Strength Cast Irons*

| *Specification or Type* | *Composition, Per Cent* | | | | | |
|---|---|---|---|---|---|---|
| | *Total C* | *Si* | *Mn* | *S (max.)* | *P (max.)* | *Others* |
| High test cast iron[1] | 3.0 - 3.3 | 1.3 - 1.5 | 0.8 - 1.0 | 0.10 | —— | —— |
| High test cast iron[1] | 2.9 - 3.1 | 1.5 - 1.8 | 0.8 - 1.0 | 0.10 | —— | —— |
| High test cast iron[1] | 2.7 - 2.9 | 1.8 - 2.0 | 0.8 - 1.0 | 0.10 | —— | —— |
| SAE 121[2] | 3.25±0.15 | 2.35±0.10 | 0.70±0.10 | 0.12 | 0.20 | Comb. C 0.60 ± 0.10 |
| SAE 122[2] | 3.00±0.15 | 2.05±0.10 | 0.75±0.10 | 0.12 | 0.15 | Comb. C 0.65 ± 0.10 |
| SAE 126[2] | 2.80±0.15 | 2.30±0.10 | 0.50±0.10 | 0.12 | 0.20 | Comb. C 0.60 ± 0.10 |
| USN 46-I-5c,[3] Class C | —— | —— | —— | 0.12 | 0.20 | —— |
| USN 46-I-5c, Class D | —— | —— | —— | 0.12 | 0.20 | —— |
| Cupola iron (70,000 p.s.i.)[4] | 2.60 | 2.15 | 0.70 | 0.08 | 0.08 | Ni 1.10 |
| Air furnace iron[4] | 2.75 - 3.00 | 1.80 - 2.20 | 0.40 - 0.60 | 0.05 - 0.08 | 0.14 - 0.18 | —— |
| Electric furnace iron[4] | 3.02 | 2.35 | 0.80 | 0.09 | 0.13 | Ni 0.44<br>Cr 0.37<br>Mo 0.58 |
| High strength wear resistant iron | 3.20 | 2.00 | —— | —— | —— | Ni 1.50<br>Cr 0.50<br>Mo 0.30 |
| Ni-Hard[5] | 3.00 - 3.40 | 1.00 - 1.50 | 0.60 - 0.90 | 0.1 | 0.2 | Ni 2.50 - 3.00<br>Cr 0.60 - 1.00 |
| Ni-Tensyliron[5] | 3.00 | 1.50 | —— | —— | —— | Ni 2.00<br>Mo 0.65 |
| 60,000 p.s.i. iron[6] | 2.95 - 3.25 | 1.50 - 2.20 | 0.70 - 0.90 | 0.09 | 0.12 | Ni 1.50 - 1.75<br>Cr 0.15 - 0.35<br>Mo 0.70 - 0.80 |
| Meehanite GC[7] | 3.0 - 3.1 | 2.0 - 2.2 | 0.6 | 0.09 | —— | Cu 1.15 |
| ASTM A126-42, Class C | —— | —— | —— | 0.12 | 0.75 | —— |

[1] From Table 229, High Test Cast Irons, p. 208, *Metals and Alloys Data Book*, Reinhold Publishing Corp.

[2] These SAE specifications correspond to those included in ASTM Spec. A159-41 (Automotive Gray Irons).

[3] No detailed chemical compositions are given in this specification.

[4] Pages 631-632 *ASM Metals Handbook*, 1939 Ed.

[5] These are trade names of the International Nickel Co.

[6] From AFA reprint "Sixty Thousand Pound per Square Inch Cupola Iron," by E. L. Roth. (Averages from 3 to 1175 lb. castings poured in 64 heats.)

[7] From "High Pressure Iron Castings," METALS AND ALLOYS, Vol. 16, Dec. 1942, p. 1108. See Footnote [4] to Table 2.

(Continued on page 1357)

# N-B-M Bronze Masterpieces Made to Order

This 600-pound bronze part for a projectile hoist is a typical N-B-M masterpiece of *precision casting*. The complex core work of this intricate pattern—the minute 1/32″ tolerance over the whole six-foot length of the rough casting—are remarkable. So is its complete freedom from porosity or shrinkage and its fine finish produced by a special type of sand.

Yet, it's just a routine job for N-B-M's skilled artisans in bronze. The more intricate your specifications, the better we like it.

N • B • M
NBM BRONZE PARTS

**NATIONAL BEARING**
DIVISION

ST. LOUIS • NEW YORK

AMERICAN
**Brake Shoe**
COMPANY

PLANTS IN. ST. LOUIS, MO. • PITTSBURGH, PA. • MEADVILLE, PA. • JERSEY CITY, N. J. • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

vanadium, molybdenum, chromium and manganese; often a combination of these is employed. Such other alloys as copper and nickel are often found in these irons largely because of their ferrite strengthening qualities, which enhance the elastic properties of the iron.

(2) Inoculated high strength irons would ordinarily be "white" as cast but they are inoculated (graphitized) in the ladle with a silicon compound (such as ferrosilicon, calcium silicide, or a Si-Mn-Zr or Ca-Mn-Si agent) usually added in the crushed form (1/8-1/4 in. mesh size). Free carbide formation is inhibited. A uniformly dense and machinable casting is poured that otherwise might either be white (or chilled) in thin sections or soft and porous in heavy sections. Both alloy and plain carbon cast irons may be inoculated.

### Heat Treatment

Cast irons having a combined carbon range of 0.5 to 0.8% and a total carbon content of 2 to 3% will respond to heat treatments in much the same manner as steels. One of the first operations many high strength iron castings undergo after being shaken out and having the fins, gates and risers removed is a stress relief (or artificial aging operation) which stabilizes the casting and reduces or prevents distortion during the subsequent machining operations. This stress relieving operation is usually accomplished by heating the castings slowly to 850 to 1150 F. (depending upon the type of iron), followed by slow cooling; such an operation should not alter the hardness and strength properties of the casting. The total cost of stress relieving in a batch type furnace should not be over $8.00 per ton.

Heat treating high strength castings for increased hardness, strength or wear resistance is accomplished by heating to temperatures of 1550 to 1600 F., followed by oil quenching and tempering at 350 to 1000 F. (Tempering at about 400 F. removes quenching stresses leaving the hardness unchanged; for maximum hardness with machinability, the castings are tempered at about 1000 F.) The influence of oil quenching on the physical properties of Meehanite, type GA, is indicated in Table 2 (see Meehanite GAH).

*Table 2.—Physical Properties of Some of the High Strength Cast Irons Listed in Table 1*

| *Specification or Name* | *Tensile Strength, p.s.i.* | *Transverse Strength,[1] lbs.* | *Transverse Defl.,[1] in.* | *BHN* | *Applications and Remarks* |
|---|---|---|---|---|---|
| SAE 121 | 40,000 min. | 2700 | 0.27-0.37 | 179-212 | Cylinders |
| SAE 122 | 45,000 min. | 3300 | 0.30-0.36 | 217-248 | Cylinders |
| SAE 126 | 45,000 min. | — | — | 228-269 | Brake drums, clutch plates, sprockets |
| USN 46-I-5c | | | | | |
| Class C | 40,000 min. | — | — | 270 max. | Miscellaneous marine machinery (pumps, etc.) |
| Class D | 45,000 min. | — | — | 280 min. | |
| Helco H-40 | 48,000 | 3200 | 0.24 | 228 | Pressure resistant castings |
| Inco A-15 | 40,000 min. | — | — | — | Medium-sized machine tool castings |
| Wear resistant | 40,000 min. | — | — | 235 | Machine tool castings subject to wear |
| Ni-Hard | — | — | — | 550-700[2] | Dies, etc. requiring great wear resistance |
| Ni-Tensyliron | 60,000 | — | — | 240 | Wear resistant, and has high impact resistance |
| Meehanite[4] GA | 50,000-55,000 | 3100-3600 | 0.30-0.36 | 196-225 | Used where high fatigue and wear resistance combined with high damping capacity is needed. |
| 60,000 p.s.i. iron | 60,000 min. | 5150-6300 | — | 241-269[3] | Typical applications are gears, sprockets, valve bodies, camshafts, etc. |
| Meehanite[4] GAH[5] | 70,000 | 5000-7000 | 0.13-0.20 | 275-600 | Similar to GA; used for drawing and cupping dies |
| Meehanite GC | 40,000 | 2900-3300 | 0.26-0.34 | 192 min. | Small pressure resistant castings, for extruding dies (when chilled), a low expansion material |
| ASTM A48-41 | | | | | |
| Class 40 | 40,000 min. | 2600 | — | — | General purpose materials |
| Class 50 | 50,000 min. | 3000 | — | — | General purpose materials |
| Class 60 | 60,000 min. | 3400 | — | — | General purpose materials |
| ASTM A126-42 (Class C) | 41,000 | 4000[7] | 0.12 | — | For valves, flanges and pipe fittings |

[1] 1.2-in. diam. test bar, 18 in. between supports.

[2] Depending whether the castings are sand or chill cast.

[3] Hardness range of castings weighing 3 to 138 lb.

[4] "Meehanite" is the trade name of a series of cast irons manufactured under process patents controlled by the Meehanite Research Institute of America, Inc. Other trade-named high-strength irons are "Praferal," "Sorbo-Mat," etc.

[5] Type GA Meehanite after heat treatment. (The resulting hardness will depend upon the tempering temperature used.)

[6] For description of dies made of Meehanite, see *Tool and Die Journal*, Vol. 9, July 1943; "Application of Meehanite to Dies and Molds," by G. Hobman, p. 90-95.

[7] 1.2-in. diam. test bar, 12 in. between supports.

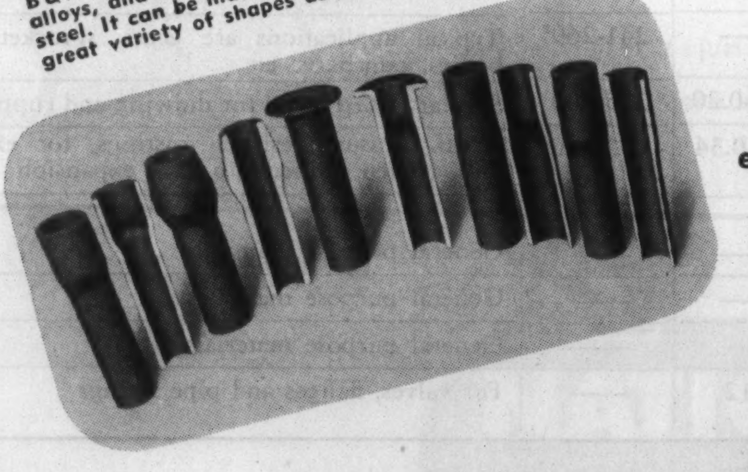
*Compiled by Robert S. Burpo, Jr.*

*Photo by U. S. Army Signal Corps.*

**B&W Mechanical Tubing is being used by the Armed Forces for gun mounts, tank and tractor parts, rockets, burster shells, ammunition containers, fragmentation bombs, range finders and $CO_2$ bottles.**

# "on target"... WITH B&W TUBES

**B&W Seamless Tubing can be furnished in carbon steels, carbon molybdenum steel, B&W Croloys, S.A.E. alloys, high-strength alloys, and stainless and corrosion-resistant steel. It can be machined and formed into a great variety of shapes as shown here.**



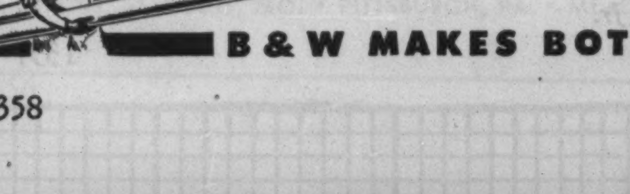
**Anti-aircraft gunners depend on the accuracy of this range finder to get them "on target." Many tube users are depending on Babcock & Wilcox to get them "on target" when it comes to selecting the tubing best suited to their mechanical needs. They know that from B&W they can always be certain of getting *unbiased* recommendations on their tube problems. That's because B&W furnishes tubing for practically any mechanical requirement, and is therefore in a position to match tubing to individual jobs without prejudice toward any type.**

**So, if you have a mechanical job for tubing to do, and if you're in doubt as to what type to choose, let B&W engineers help you select the right one. Their impartial advice is backed by more than 20 years of tube engineering and manufacturing, plus research that has produced a long list of "firsts" in tubing development.**

## B&W TUBES

SEAMLESS. Complete range of carbon and alloy steels
Sizes: 1/2 in. to 8 5/8 in. O.D.
ELECTRIC-RESISTANCE WELDED. Carbon grades
Sizes: 3/4 in. to 4 in. O.D.

**THE BABCOCK & WILCOX TUBE COMPANY**
Seamless Tube Division
BEAVER FALLS, PA.
Welded Tube Division
ALLIANCE, OHIO



**B&W MAKES BOTH**

TA-1290

METALS and ALLOYS

# Engineering File Facts

NUMBER 81
May, 1945

MATERIALS AND DESIGN
Glass

## Glass as an Industrial Material

| Type | Preparation | Composition, Sizes, Etc. | Uses |
|---|---|---|---|
| **Sheet Glass** | | | |
| Window | Drawn vertically from the molten bath as a continuous sheet, firepolished and annealed. Shows only slight wave or distortion. | Soda-lime glass. Thicknesses from very thin to ¼ in. max. standard sheets 76 in. x 120 in. | For general purpose glazing of building. Also for table tops, induction heating jigs, shields, electrical insulators, small mirrors, etc. Thin sheets for photographic and microscopical uses. |
| Tempered | Glass is quickly heated to about 1150 F. and chilled quickly. Strength increased 2-5 times. | Same as above—must be cut to size, drilled, etc., before tempering. | For gage glasses, safety mirrors, business machine windows, fire screens, hospital glazing, etc. |
| Wire | Wire mesh is embedded in the molten glass. | Sometimes uses heat-absorbing types of glass. | For skylights, roofing, air raid precautionary glazing, etc. |
| Heat-Resisting | Special compositions, usually of borosilicate type. | | For oven sight glasses, heat protection shields, electrical insulators, furnace door glasses, etc. |
| Ultraviolet | Glass of a special composition to transmit about 50% of the ultraviolet rays in solar radiation. | | For hospital sun porches, greenhouses, poultry houses, etc. |
| Water White | An exceptionally "white" glass with higher light transmission. | | For greenhouses, picture glazing, photographic uses, etc. |
| Light Reducing | Blue-tinted glass for cutting down amount of sunlight transmitted. | | For glazing in sunny climates. |
| Colored | Obtainable in a wide range of colors, transparent and translucent. Plain and varigated colors. | | For ornamental glazing, decorative panels, modern furniture. |
| Figured | A figure is rolled into the glass to diffuse or otherwise reduce lighting. | | For obscured windows, skylights, glare-reducing windows, etc. |
| Polarizing | Glass is coated with a chemical that polarizes the light transmitted. | | For anti-glare applications, as sunglasses. |
| **Plate Glass** | | | |
| Rough Rolled | Rolled to sheet form with a knurled surface in a variety of patterns. | Soda-lime glass. Standard thicknesses 3/16 in. to 1¼ in. in usual grades. | The rough stock for manufacture of plate glass. Also used for ornamental glazing, obscured windows, skylights, etc. |
| Polished | Rough rolled stock ground and polished to substantially optical flatness of surface. | Standard thicknesses 7/64 in. to 1¼ in. | For tracing tables, surface plates, blueprint machines, and show windows and counters, illuminated signs, mirrors, windows, doors, stairways, walls, etc. |
| Tempered | Plate glass is rapidly heated to about 1150 F. and cooled suddenly in a blast of air. Strength is increased to 4 or 5 times that of ordinary plate. | Same as above—must be cut to size before tempering. | For pickling tanks, gage glasses, pressure tanks, oven sight glasses, store front panels, advertising signs, etc. |
| **Special Purpose** | | | |
| X-Ray | Specially prepared with lead content of about 61%, and lead equivalent of about 0.32. About ¼ in. thickness. About twice as heavy as ordinary plate glass. | | For X-ray protection. |
| Water White | Special composition to provide higher transmission of all light. | | For photographic and blueprint purposes, refrigerated showcases, display windows, etc. |
| Document | Designed to cut down the amount of ultra-violet light transmitted. About ¼ in. thickness. | | For protection of old documents and collections in museums. |
| Heat Absorbing | A blue-tinted glass transmitting 70% of solar light but only 45% of the heat. | | For double-glaze units on trains, skylights, airport control towers. |
| Colored | Blue, flesh-tinted, and other colors are produced in transparent and opaque glasses. | | For decorative mirrors, panels, chalkboards, bulletin boards, etc. |
| **Laminated Glass** | | | |
| Safety Plate | Two or more lights of glass bonded by interlayers of transparent plastic. | Plate glass—composite is usually ¼ in. thick. | For automobile windshields and windows, aircraft and bus glazing, railroad car windows, protective shields, jewelry store windows, safety lenses, etc. |
| Safety Sheet | | Sizes from about 3/32 in. to ½ in. | |

(Continued on page 1361)

THE Stainless Surface Hardening Process provides the free machining Stainless Steels, Types 416 and 303 with 1100-1200 Brinnell surface hardness. Penetration depths of .020″ on the 12-14% Chromium Type, and .010″ on the 18-8 Type Stainless Steels are readily obtained.

Austenitic as well as martensitic grades of Stainless Steel now can be hardened by this process . . . and parts machined to nearly exact dimensions require only a light grinding or lapping after processing.

The Stainless Surface Hardening Process insures greatly increased abrasion resistance for highly stressed parts in which heat treatment has developed greater tensile strength, ductility and impact resistance. Core properties are not altered.

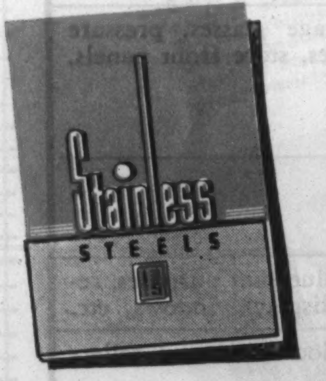
Today—write or call for complete information on how the Stainless Surface Hardening Process will extend the service life of the Stainless Steel parts of *your* product.

***This efficient new process gives Stainless 1100 Brinell surface hardness!***

***That assures longer service life for Stainless Steel parts of my product!***

"Our drills must resist corrosion *and* abrasion," says a prominent manufacturer of dental instruments, "And that's why Stainless Steel parts treated by the Stainless Surface Hardening Process solved our problem." The business end of a dental drill is only 3 inches in overall length, yet it includes 16 wearing surfaces—all subjected to the possibility of corrosion by mouth acids as well as the abrasive action of carborundum and tooth enamel dust. Surface hardened Stainless Steel makes it possible to produce trouble-free instruments with almost unlimited service life.

• • • •



### AND WHEN YOU NEED STAINLESS STEELS . . .

Whatever your Stainless requirements — sheets, bars, tubing, wire, valves, fittings, even bolts and nuts—Industrial's inventory is complete and comprehensive . . . and you'll receive same-day attention to your order. One way to save valuable time and needless bother . . . one way to speed all your Stainless requirements to your plant . . . is to place your entire order with Industrial—where the largest and most diversified warehouse stock of Stainless Steels in America is maintained. Expert metallurgists at Industrial will assist you with any Stainless specification or fabrication problem. Complete catalog sent on request. INDUSTRIAL STEELS, INC., 250 Bent Street, Cambridge 41, Mass.

JMLco CS-81

## STAINLESS SURFACE HARDENING CO.

255 BENT STREET • CAMBRIDGE 41, MASS.

SUBSIDIARY OF INDUSTRIAL STEELS, INC.

| Type | Preparation | Composition, Sizes, Etc. | Uses |
|---|---|---|---|
| **Bullet Resisting Plate**<br>**Bullet Resisting Sheet** | Several lights of glass, usually three, laminated as for safety plate. | Standard thicknesses from ½ in. to 1½ in. | Primarily for protection against firearms, as in banks, money collecting trucks, police cars. Also for protective shields in laboratories. |
| **Double Glass** | Not strictly a laminated glass—2 lights are separated by cemented glass spacer around edges, leaving air space between. | Must be made to order as to sizes—usual thickness is two ⅛-in. lights with ⅛-in. space. | For glazing air conditioned buildings, railway cars, etc. |
| | | **Formed Glassware** | |
| **Pressed Ware** | Molten glass is pressed into a mold, by hand or automatically. Metal inserts or attachments may be used. Parts may be tempered. | Compositions to suit requirements. Borosilicate glasses where thermal resistance or extra strength is required. Lead glass or soda-lime-magnesia-alumina for household ware. | For electrical insulators, centrifugal pump parts, glass gages, godet wheels, rotary valves, sight glasses, etc. for industry; household utensils, tableware, decorative glass articles, etc., for commercial fields. |
| **Blown Ware** | Molten glass is blown into a mold to produce hollow forms. Work may be done by hand or automatically. Parts may be tempered. | Frequently a soda-lime-magnesia-alumina glass is used because of its easy workability. Heat resisting glasses or other special compositions where desired. | For bottles and similar containers, battery jars, floats, laboratory glassware, reaction columns, lantern globes, domestic utensils, etc. |
| **Drawn Ware** | Glass is drawn directly from the melting furnace in some standard form. | A variety of compositions can be used, usually soda-lime-magnesia-alumina or a heat-resisting variety. | For tubing, glass pipe, rods, gage glasses, and similar forms. |
| **Multiformed** | Glass is cold molded to close tolerances and sintered. Wide range of shapes. | A variety of compositions can be used. The glass usually is white and translucent. | For electrical insulators, pump seal rings, etc. |
| | | **Glass Fiber Materials** | |
| **Batts** | Very fine glass filaments drawn out from molten glass and collected as a woolly mass—may be treated with a resin binder and compacted to any desired degree, or faced with wire mesh. Forms a non-absorptive, non-combustible, chemically resistant material having good sound-, heat-, and electrical-insulating properties. | | For insulation of military aircraft, domestic stoves, roofs of industrial buildings, railroad tank cars; as tower packing; insulation of furnaces; sound deadening in test rooms, as a dust filter in air conditioning. |
| **Blocks** | Mats of glass fiber compacted to blocks or boards under pressure and held with a binder. Available in thicknesses to 2 in. for use to 600 F. for one grade, to 1200 F. for another. | | For insulation of boilers, ovens, breeching, pipes, valves, tanks; low temperature grade for refrigerated spaces. |
| **Textiles**<br>**Cord**<br>**Sleeving**<br>**Tape or Cloth** | Glass fiber filaments may be spun to threads and woven into fabric on standard textile equipment. The textile materials so produced have exceptionally high strength, exceeding that of the natural and of most other synthetic fibers, weight for weight. | | As heat insulating material—for lagging pipe, aircraft engine exhausts, etc.<br>As electrical insulation—for winding wire, for covering motor coils, ignition cable.<br>As a decorative or fireproof, or rotproof fabric—for draperies, military fabrics. |
| **Composites** | *Glass Fiber-Plastic Laminates*—an extremely high-strength plastic laminate. *Glass Fiber-Asbestos*—for high-temperature insulation. *Glass Fiber-Neoprene*—for conveyor belts to operate at elevated temperatures. *Glass Fiber-Mica*—slot insulation in motors and generators, etc. *Glass Fiber-Rubber*—for military and naval tarpaulins, etc. | | |
| | | **Glass Structural Forms** | |
| **Block** | Made by fusing together two halves of pressed glass to form a hollow, partially evacuated block. | In 3 standard sizes—5¾ in. sq., 7¾ in. sq., 11¾ in. sq., all 3⅞ in. thick. Standard radial and corner blocks available. | For light-transmitting masonry walls, interior partitions, permanent windows or panels in air-conditioned structures, etc. |
| **Cellulated** | Gas is trapped in molten glass to give a lightweight material containing numerous closed cells. | As usually made, is lighter than water. Available as blocks in sizes to 12 in. x 18 in. x 6 in. | For building blocks, thermal insulation; also for life rafts, fishing floats, etc. |
| **Cast Ornamental Panels** | Sculptured designs cast in glass, and back face frosted, polished, mirrored, etc. | In several standard patterns and modeled designs. Strip or square panels of various sizes. | For door or fireplace trim, indirect lighted panels, screens and partitions, strip decoration, fountains, etc. |

*Compiled by Kenneth Rose, Engineering Editor*

# NEW ARCOS CHROMEND 9M

GIVING

8 to 10% CHROME and 1.5% Moly Weld Deposit

For many years, metallurgists have recommended chrome-moly steels for high temperature and mild corrosion resistance work. Their recommendations have generally pointed to the 4-6% chrome ½% moly composition. Fabricating and design engineers, however, have requested properties of metals that would give greater strength and greater corrosion resistance combined with high creep resistance. Arcos Chromend 9M is developed to meet the welding requirements of this grade.

**CHROMEND 2 M** 2% CHROME MOLYBDENUM ELECTRODES

**CHROMEND 5 M** 4-6% CHROME MOLYBDENUM ELECTRODES

**CHROMEND 9M**

**CHROMEND 12** 12% STRAIGHT CHROME ELECTRODES

**CHROMEND 16** 16% STRAIGHT CHROME ELECTRODES

**CHROMEND 18** 18% STRAIGHT CHROME ELECTRODES

**CHROMEND 28** 28% STRAIGHT CHROME ELECTRODES

## ARCOS CHROME NICKEL GRADES

CHROMEND 16/7
CHROMEND KS 18/8 SI
CHROMANG 19/9 Mn
CHROMEND K 19/9
STAINLEND K 19/9 Ac
CHROMEND HC 25/12
STAINLEND HC 25/12 Ac
CHROMEND 25/12 Cb
CHROMEND HCN 25/20
STAINLEND HCN 25/20 Ac
CHROMEND 25/20 Cb
CHROMEND 25/20 Mo
CHROMEND HN 17/25
CHROMEND 29/9
CHROMEND K Mo 18/12 Mo
STAINLEND K Mo 18/12 Mo Ac
CHROMEND K Mo Cb
CHROMEND 18/8 Mo
CHROMEND 8/18
CHROMEND 25/3 Mo
CHROMEND 15/35
STAINLEND 15/35 Ac
CHROMEND 19/9 Cb
STAINLEND 19/9 Cb Ac
CHROMEND 19/9 W Mo
CHROMEND 13/60
CHROMEND 14/75
CHROMEND 20/80
CHROMEND 15/85

## ARCOS CHROME GRADES

## ARCOS MISC. GRADES

MIXEND
NICKELEND
CHLOREND B
CHLOREND C
BRONZEND E
BRONZEND P
CAREND
REFORMEND
MANGANEND 2M
MANGANEND 13
CUTTEND Under Water Cutting

ARCOS

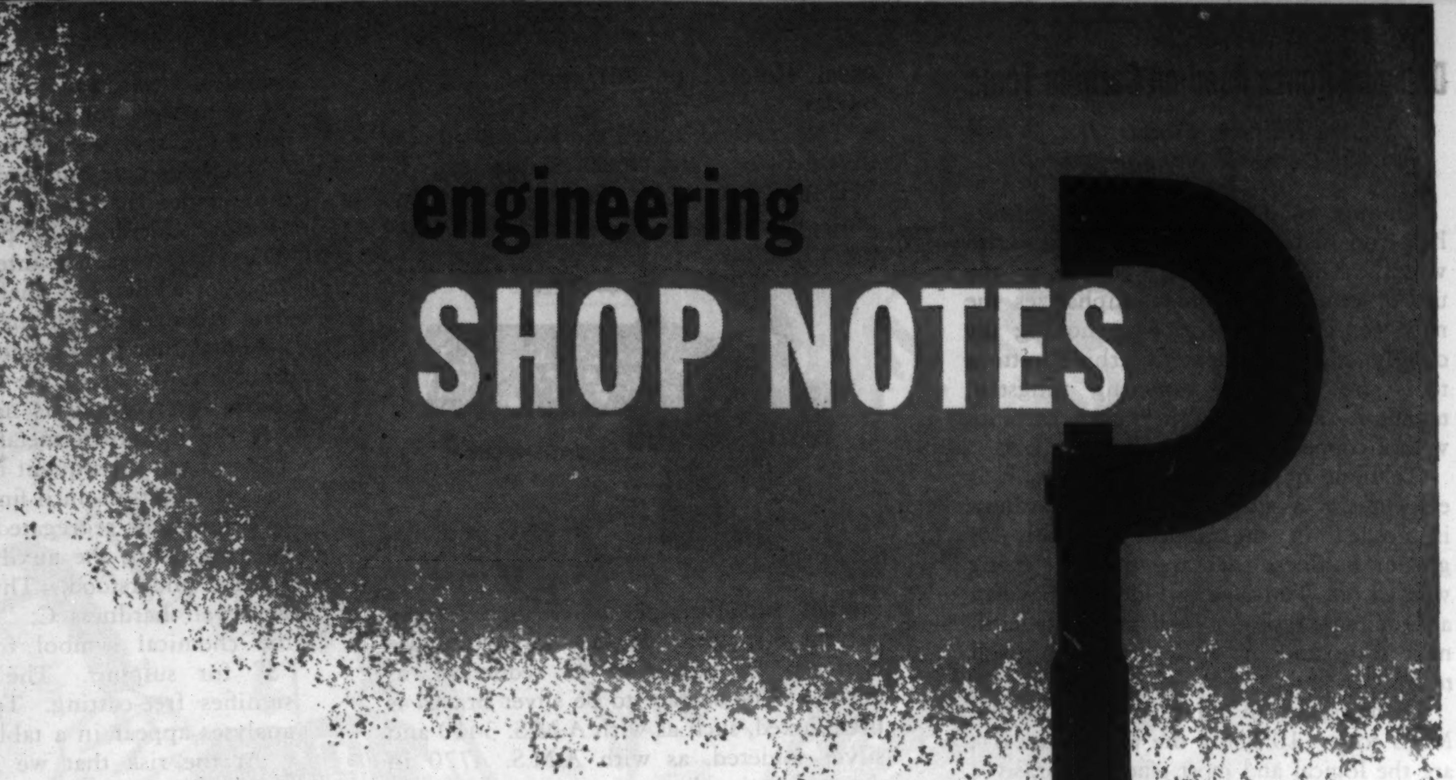
ARMY NAVY

ARCOS CORPORATION • 407 N. BROAD ST., PHILA. 8, PA.

*Your Arcos Distributor knows the Answers. Your Arcos Distributor has Stock.*

| | |
|---|---|
| Baton Rouge 17, La. | Louisiana Welding Supply Co. |
| Borger, Texas | Hart Industrial Supply Co. |
| Boston, Mass. | H. Boker & Co., Inc. |
| Buffalo, N. Y. | Root, Neal & Co. |
| Chicago, Ill. | Machinery & Welder Corp. |
| Cincinnati, Ohio | Williams & Co., Inc. |
| Cleveland, Ohio | Williams & Co., Inc. |
| Columbus, Ohio | Williams & Co., Inc. |
| Detroit, Michigan | C. E. Philips & Co., Inc. |
| Erie, Penna. | Boyd Welding Co. |
| Fresno, Calif. | Victor Equipment Co. |
| Ft. Wayne, Ind. | Wayne Welding Sup. Co., Inc. |
| Honolulu, Hawaii | Hawaiian Gas Products, Ltd. |
| Houston, Texas | Champion Rivet Co. of Texas |
| Kansas City, Mo. | Welders Supply & Repair Co. |
| Kingsport, Tenn. | Slip-Not Belting Corp. |
| Los Angeles, Calif. | Victor Equipment Co. |
| Milwaukee, Wis. | Machinery & Welder Corp. |
| Moline, Ill. | Machinery & Welder Corp. |
| Montreal, Canada | G.D.Peters & Co. of Canada, Ltd. |
| New Orleans 13, La. | Gulf Welding Equip. Co. |
| New York, N. Y. | H. Boker & Co., Inc. |
| Oklahoma City, Okla. | Hart Industrial Supply Co. |
| Pampa, Texas | Hart Industrial Supply Co. |
| Pittsburgh, Pa. | Williams & Co., Inc. |
| Portland, Ore. | J. E. Haseltine & Co. |
| Rochester, N. Y. | Welding Supply Co. |
| San Diego, Calif. | Victor Equipment Co. |
| San Francisco, Calif. | Victor Equipment Co. |
| Seattle, Wash. | J. E. Haseltine & Co. |
| Spokane, Wash. | J. E. Haseltine & Co. |
| St. Louis, Mo. | Machinery & Welder Corp. |
| Syracuse, N. Y. | Welding Supply Co. |
| Tulsa, Oklahoma | Hart Industrial Co. |
| Wichita, Kansas | Watkins, Inc. |

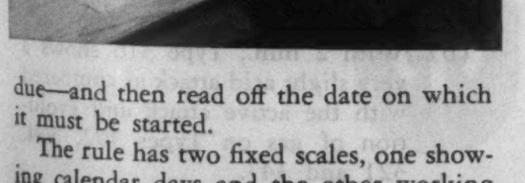
# engineering SHOP NOTES



## Scheduling Slide Rule

*by George Wollinger,*
*Glenn L. Martin Co.*

A new type of slide rule has been devised at the Martin plant to translate days on the calendar into working days, since, of course, there are Sundays and holidays which must be allowed for in scheduling production. To determine how many days before final test it will be necessary to start the keelson of a Martin bomber, or at what date detail parts would have to be on the floor, it is only necessary to set the working days scale for the number of days required to build the part or assembly and the calendar days scale for the date on which the part is due—and then read off the date on which it must be started.



The rule has two fixed scales, one showing calendar days and the other working days; also a double removable scale which is calibrated in straight numerical graduations and runs both forward and backward.

Prior to the introduction of the scheduling slide rule, long periods of counting off the days on the calendar and computing results were required to produce the same information. At best this took minutes as against seconds for the new device. In some cases, where there was a several months' interval between the date to be ascertained and the known date, the computation period might even run into hours.

The accompanying photo depicts the author and designer of this slide rule.

## Resistance-Welded Round Corners

*by R. F. Wyer,*
*General Electric Co.*

A fast economical method of producing smooth and uniformly rounded corners, such as on covers of boxes used in the electrical industry, involves resistance welding. The corners of the sheet are first notched and trimmed, the notch somewhat resembling the space between leaves of a 4-leaf clover.

Then the edges are formed with a straight bending brake and the corners are given their rounded contour by a corner die. Because of variations in sheet stock, the joint or crack in the corner does not always fit closely. Therefore, a narrow strip of thin steel, about 0.040 in. stock, is resistance-welded to the outside of the corner.

The welder has electronic control and special clamping electrodes that conform to the contour of the corner. During welding, some of the metal from the steel strip flows into the corner crack. An abrasive disk removes excess metal, thus giving a smooth, strong, water-tight corner.

---

*We have saved 650 man-hours formerly spent grinding the tools that cut grooves in Micarta plastic pulleys of bomber plane controls. Resharpening the edges of the tool was lengthy because the grinding wheel touched the entire top surface of the tool and became clogged with particles of softer metal. The grinding wheel had to be resurfaced often to prevent finishing the tool at an incorrect angle. Therefore, we cut a notch in the tool just behind the hard metal tip and then machined away a thin slice of the tool behind this notch, leaving only a small top surface that touches the wheel—the bulk of the material that was clogging the wheel has already been removed by machining.*

—E. J. Pratt, Westinghouse,
Trafford, Pa.

## Diamond Hones Used on Carbide Tools

*by Harry L. Strauss, Jr.,*
*National Diamond Hone & Wheel Co.*

Honing of tool cutters is a definite help, no matter what type of tool is involved. The phenomenal growth of the use of cemented carbides emphasizes the need for greater attention to honing the cutting edges. Cemented carbide cutting tools are made by sintering tungsten, tantalum carbide or other hard carbides with a copper, nickel or cobalt binder.

To hone or abrade away carbide, it is evident that a substance of great hardness is needed in the hone, preferably of greater hardness than the material being worked on. Tungsten carbide will have an approximate rating of 9 in the Mohs hardness scale and A 80 on the Rockwell tester.

Diamonds, with a rating of 10 on the Mohs scale (10 being the top hardness), are the logical and most efficient abrasives for carbides, when in the form of diamond hones. When powdering the diamonds for abrasive use, the diamonds obligingly break up along their lines of crystallization. Not only are the diamond grits very hard, but they break off with fine keen edges of high cutting value.

Compared with other abrasives, the diamond cuts faster and gives a better finish if proper grit size is used. An Eastern tool and production shop reports the following experience to the National Diamond Hone & Wheel Co., New York:

A carbide tool was being ground to specifications. Before inserting in a turret lathe, it was finish-honed with a No. 3 hone, of fine grit and heavy concentration, which gave the tool a very high finish. The set-up man reported that it outlasted unhoned tool bits over 1½ times before work showed evidence of a tool becoming dull. When dullness finally became evident, a rough grit, No. 5, honed off the broken-down carbide edge. It was then repolished with the fine No. 3 hone.

The following advantages became evident: Tool life became longer; longer periods intervened between regrinds; savings on costly diamond wheels resulted; a better finish on the work was evident; less time and labor were needed to remove the tool; and the machine was idle a shorter period.

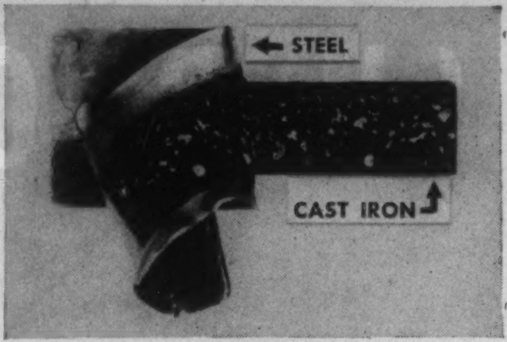
Friction of a tool on the work is greatly reduced by honing, thereby lessening the surface stress on the carbide. Carbide is susceptible to breaking away on the cutting edges if the tool is not properly honed.

## Preparing Cast Iron for Silver Brazing

*by J. H. Shoemaker,*
*Kolene Corp.*

Commercial silver soldering or brazing of cast iron to steel, other ferrous or some non-ferrous metals, has heretofore been considered impractical. However, we have discovered a process whereby we remove graphite, combined carbon and sand inclusions (necessary from a physical standpoint but undesirable from a bonding standpoint) from the surface of cast iron, thereby making the silver brazing feasible. This removal is in addition, of course, to usual removal of dirt, grease, oil and oxides.

This method, called the Kolene process, invented by our chief chemist, H. G. Webster, consists of suspending cast iron parts in an open container of catalyzed molten salts through which an electrical current is passed. Surface impurities are removed by oxidation or reduction, as desired. The surface to be silver brazed is then fluxed, such as with A.M.S. 3410 and silver soldered, as with A.M.S. 4770 in the conventional manner.



It has been found possible with this process to join steel stampings, tubing, pipe, etc. to cast iron fittings and parts.

Figure 1 illustrates a breach of a joint between silver brazed cast iron and steel. The strength of the bond is shown by the fact that the cast iron has ruptured—not the bond.

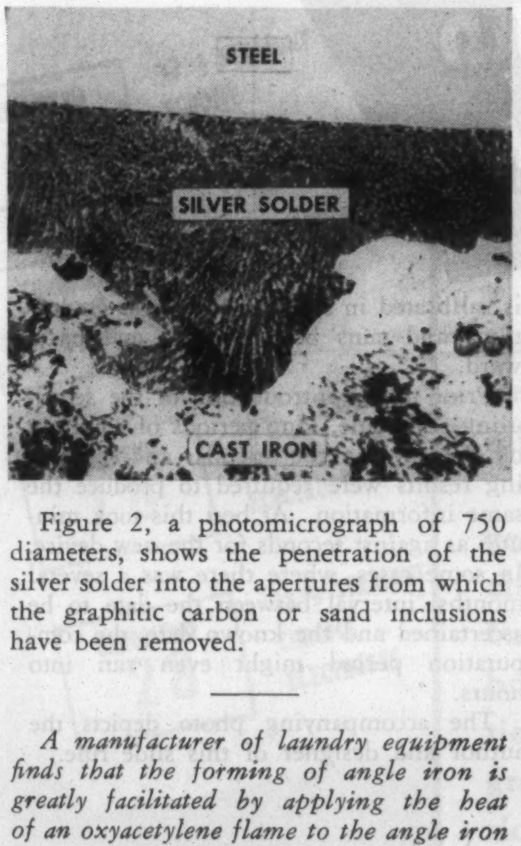


Figure 2, a photomicrograph of 750 diameters, shows the penetration of the silver solder into the apertures from which the graphitic carbon or sand inclusions have been removed.

---

*A manufacturer of laundry equipment finds that the forming of angle iron is greatly facilitated by applying the heat of an oxyacetylene flame to the angle iron at a point just ahead of the roll that forms the angle iron against the bending block.*

—Linde Air Products Co.

---

## Spot Identification of Stainless Steels

*by H. W. Miller,*
*Carpenter Steel Co.*

When stocks of materials are mixed or unidentified, yet have the same external appearance, it is desirable to have at hand a method that quickly tests the various pieces so that kinds can be segregated. It is often necessary to identify stainless steels. Carpenter Steel Co. has devised a few easy methods for identifying their stainless steels, and this could well be applied to steels of other makers, especially since the analyses are herewith presented.

Methods here outlined are useful to separate types that show marked differences in their chemical and physical properties. These tests are not intended to take the place of a chemical analysis where precise data are needed. In these spot tests, it is assumed that the operator has some technical knowledge of the alloys in question.

The first spot tests naturally only classify the unknown metal into broad divisions. Each subsequent test narrows down the classification until finally the X-sample is completely segregated. In the accompanying chart, the auxiliary notations are readily understood. Thus, "Rc" denotes Rockwell hardness C; "Se" is, of course, the chemical symbol for selenium, and "S" for sulphur. The "F" in "420F" signifies free-cutting. Type numbers and analyses appear in a table.

At the risk that we may be insulting the intelligence of our readers, we warn that all specimens must be free from scale, which may be removed by pickling or grinding. In making a spot test, always grind a fresh area before applying the solution.

In the accompanying chart, the letters in parenthesis, a to d, refer to various muriatic acid tests, mentioned in the text under heading of "Identification Tests," below:

### *Identification Tests*

*Nitric Acid Test*—The solution is made by mixing one part of concentrated nitric acid and one part of water. A drop is placed on the specimen. Attack is denoted by a boiling action or gas evolution from the drop.

*Magnet Test*—Austenitic stainless steels (the 18-8 types) are non-magnetic in the annealed condition, but become slightly magnetic when cold-worked. This slight magnetism can easily be distinguished from the stronger magnetism of the straight chrome types.

*Spark Test*—A spark test is made to separate stainless types 420 and 440 from non-ferrous alloys and ordinary iron and steel, as nitric acid under certain conditions may attack annealed specimens of some stainless types. These stainless steels emit a short "chrome" spark.

*Hardness Test*—Specimens are heated to 1850 F. and oil quenched. Various carbon percentage ranges will be noted by different hardnesses as quenched. The non-hardening types will show low hardness as oil quenched from 1850 F.

*Muriatic Acid Tests*—Specimens are placed in a solution of muriatic acid (one part water, one part muriatic acid) at 180 to 190 F. A fresh solution should be used for each of the following tests:

(a) After 5 min. immersion, Type 303 will be coated with a heavy black smudge.

(b) With 2 min., Type 316 shows a very slight acid attack as compared with the active attack and evolution of gas on Types 302, 304, 321 and 347.

(c) Immerse specimens for at least 15 min. Type 443 shows a brown-

*(Continued on page 1366)*

# So Now Brownie Is Happy With A.C.

I HEARD a stricken moan and looked over at Brownie, my boss. He's our Purchasing Agent and so has a right to look unhappy—decent supplies being as scarce nowadays as prospective husbands. But I never did see him look this sunk before.

"Miss Jones," he groaned, meaning me, "I got troubles. For years our Welding Department has done a swell job with D.C. equipment and Murex electrodes. You know: FHP for downhand work, Fillex for fast fillet welding, Genex for tacking and fitup, Type M or Type 90 for high tensile steels, and so on. Now the department's installing some A.C. units, and I have to try to locate and stock a whole new group of electrodes. I feel like sticking my head in an eight-ton drop hammer and Ending It All."

"You'll do better," I said, "to stick your head in the Welding Department and ask for Joe, the foreman. And I'm going with you, to see you two don't come to blows about this."

But Joe, who's the excitable kind himself, just sort of tut-tutted poor Brownie's worries.

"Mr. Brown," Joe said, grinning, "every pound of Murex we have in stock works on both D.C. *and* A.C., including the Stainless. In fact, one of our A.C. units is already running, and going along swell on Murex."

Brownie practically collapsed on the nearest chair, he was that relieved. I felt the same way, knowing what troubles Joe's knowledge of Murex had saved me.

"And while you're here," Joe smiled, "you might take a request. Stock me some Murex Type A for vertical and overhead work on A.C., and some of their Alternex, which also does an extra-swell job on A. C. Meanwhile, forget your worries. Except for their type E6012 and E7012, practically all regular Murex electrodes work as well on alternating current as on direct."

P.S. Miss Jones back again. I found out later how Joe happened to know things about Murex my own boss didn't know. He has one of those big Murex wall charts, dividing their thirty-odd electrodes by use on mild steels, low alloys, stainless, and hard-surfacing. It also shows at a glance the AWS-ASTM grade, polarity, current, etc., of each electrode. I wrote for one for Brownie, and I think no Purchasing Agent in a plant that does welding should be without one. You just drop a line to:

**METAL & THERMIT CORPORATION**
**120 BROADWAY, NEW YORK 5, N.Y.**
**ALBANY • CHICAGO • PITTSBURGH**
**SO. SAN FRANCISCO • TORONTO**

**MUREX Electrodes**

ish colored smudge.

(d) Immerse specimens in a separate container for 5 min., then remove from the solution. A pungent garlic-like odor will be detected on Types 416 (Se) and 440F. This characteristic odor of hydrogen selenide gas will not be present in pickling Types 410 and 440.

*Sulphur Spot Test*—Three drops of sulphur acid solution (one part sulphuric acid, three parts water) are placed on the specimen and allowed to react for 1 min. One drop of a 5% solution of lead acetate in water is then added to the acid drop and allowed to react for 15 sec. The spot is then washed with water and examined. A positive test for sulphur (stainless types 416 (S), 420F and 430F) is the presence of a black sulphide deposit.

*Nickel Spot Test*—Three solutions are required for this test:

Solution No. 1—Mix 125 cc. of water, 100 cc. concentrated nitric acid, and 25 cc. of 85% phosphoric acid.

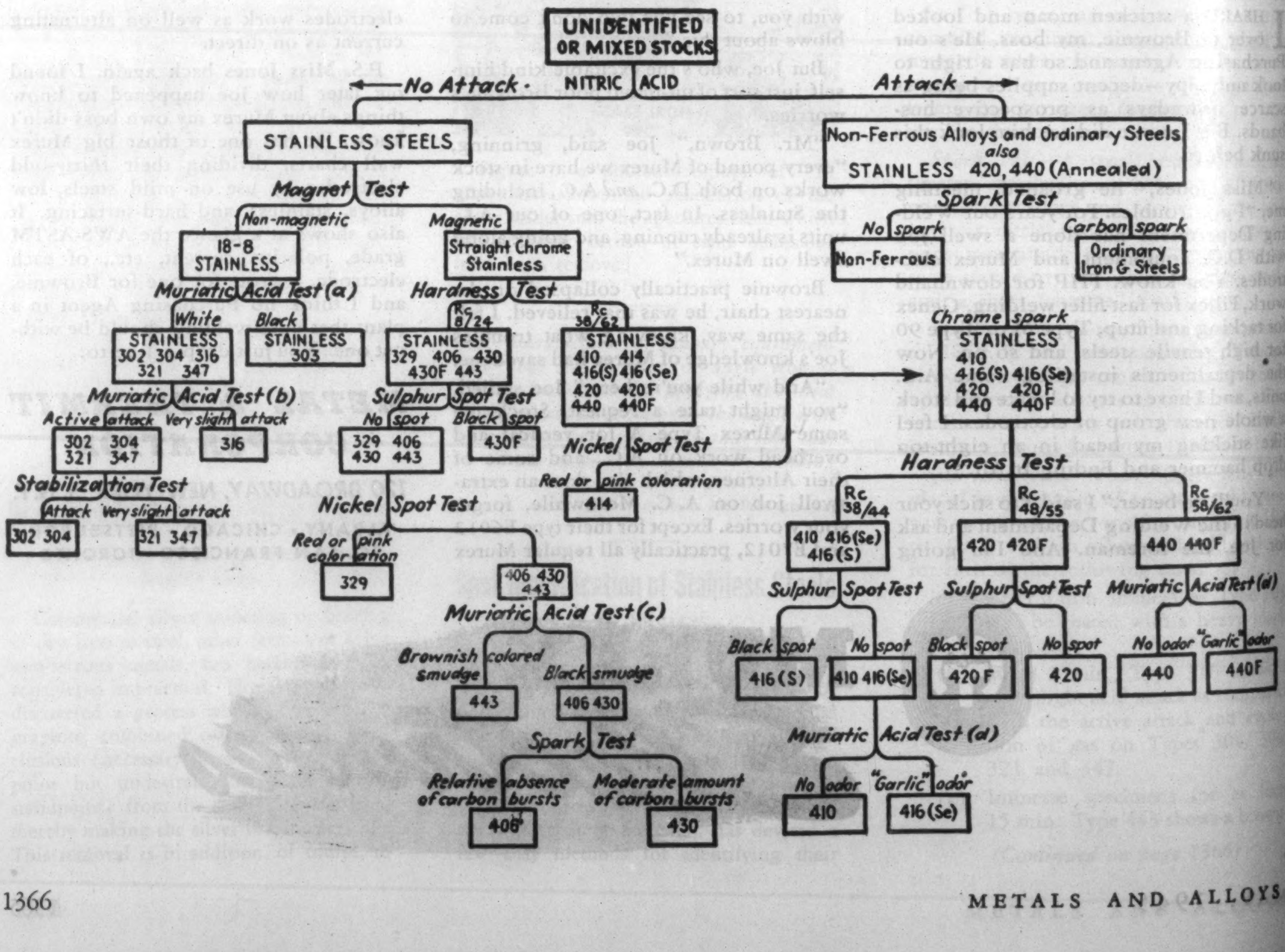
Solution No. 2—One part water and one part muriatic acid.

Solution No. 3—Dissolve one gram of dimethylglyoxime in 60 cc. of glacial acetic acid. To this solution add another solution, prepared by dissolving 10 grams of ammonium acetate in 30 cc. of ammonium hydroxide.

Procedure: Place one drop of solution No. 1 on the specimen. Allow it to react for 30 sec. and then add one drop of solution No. 2. This mixture reacts for an additional 30 sec. and is then absorbed with white blotting or filter paper. One drop of solution No. 3 is then placed on the moist spot of the paper. The formation of a red or pink coloration in the spot denotes nickel.

*Stabilization Test*—Test specimens are heated to 1250 F. for 2 hr., furnace cooled to 800 F., and then cooled to room temperature in air. The specimens are then placed in a cold solution of three parts nitric acid, one part hydrofluoric acid and six parts water. Stainless types 321 and 347 will show a very slight attack from the acid. Stainless types 302 and 304 will have rough, granular surfaces.

| Type | Carbon | Chromium | Nickel | Other Elements |
|---|---|---|---|---|
| 302 | Over 0.08/0.20 | 17.00/19.00 | 8.00/10.00 | Mn 2.00 max. |
| 303 | 0.20 max. | 17.00/19.00 | 8.00/10.00 | Mn 2.00 max.; S or Se 0.07 min.; Mo 0.60 max. |
| 304 | 0.08 max. | 18.00/20.00 | 8.00/10.00 | Mn 2.00 max. |
| 316 | 0.10 max. | 16.00/18.00 | 10.00/14.00 | Mn 2.00 max.; Mo 1.75/2.50 |
| 321 | 0.10 max. | 17.00/19.00 | 8.00/11.00 | Mn 2.00 max.; Ti 4 x carbon min. |
| 329 | 0.20 max. | 23.00/28.00 | 2.50/ 5.00 | Mo 1.00/2.00 |
| 347 | 0.10 max. | 17.00/19.00 | 9.00/12.00 | Mn 2.00 max.; Cb 8 x carbon min. |
| 406 | 0.15 max. | 12.00/14.00 | | Aluminum 3.50/4.50 |
| 410 | 0.15 max. | 11.50/13.50 | | |
| 414 | 0.15 max. | 11.50/13.50 | 2.50 max. | |
| 416 | 0.15 max. | 12.00/14.00 | | S or Se 0.07 min.; Mo 0.60 max. |
| 420 | Over 0.15 | 12.00/14.00 | | |
| 420F | Over 0.15 | 12.00/14.00 | | S or Se 0.07 min.; Mo 0.60 max. |
| 430 | 0.12 max. | 14.00/18.00 | | |
| 430F | 0.12 max. | 14.00/18.00 | | S or Se 0.07 min.; Mo 0.60 max. |
| 440 | Over 0.12 | 16.00/18.00 | | |
| 440F | Over 0.12 | 16.00/18.00 | | S or Se 0.07 min.; Mo 0.60 max. |
| 443 | 0.20 max. | 18.00/23.00 | | Cu 0.90/1.25 |


UNIDENTIFIED OR MIXED STOCKS
NITRIC ACID
No Attack
Attack
STAINLESS STEELS
Magnet Test
Non-magnetic
Magnetic
18-8 STAINLESS
Straight Chrome Stainless
Muriatic Acid Test (a)
White
Black
STAINLESS 302 304 316 321 347
STAINLESS 303
Muriatic Acid Test (b)
Active attack
Very slight attack
302 304 321 347
316
Stabilization Test
Attack
Very slight attack
302 304
321 347
Hardness Test
Rc 8/24
Rc 38/62
STAINLESS 329 406 430 430F 443
STAINLESS 410 414 416(S) 416 (Se) 420 420F 440 440F
Sulphur Spot Test
No spot
Black spot
329 406 430 443
430F
Nickel Spot Test
Red or pink coloration
414
Nickel Spot Test
Red or pink coloration
329
406 430 443
Muriatic Acid Test (c)
Brownish colored smudge
Black smudge
443
406 430
Spark Test
Relative absence of carbon bursts
Moderate amount of carbon bursts
406
430
Non-Ferrous Alloys and Ordinary Steels also STAINLESS 420, 440 (Annealed)
Spark Test
No spark
Carbon spark
Non-Ferrous
Ordinary Iron & Steels
Chrome spark
STAINLESS 410 416(S) 416(Se) 420 420F 440 440F
Hardness Test
Rc 38/44
Rc 48/55
Rc 58/62
410 416(Se) 416(S)
420 420F
440 440F
Sulphur Spot Test
Sulphur Spot Test
Muriatic Acid Test (d)
Black spot
No spot
Black spot
No spot
No odor
"Garlic" odor
416(S)
410 416(Se)
420 F
420
440
440F
Muriatic Acid Test (d)
No odor
"Garlic" odor
410
416(Se)

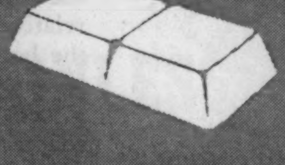
## Metal-Working Industries

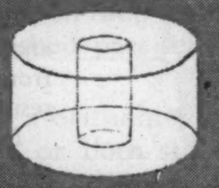
# ENGINEERING DIGEST

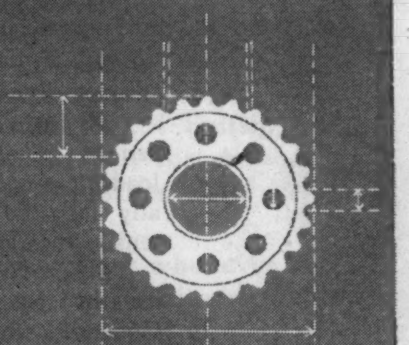
**A selection of outstanding articles on engineering materials and processing methods**

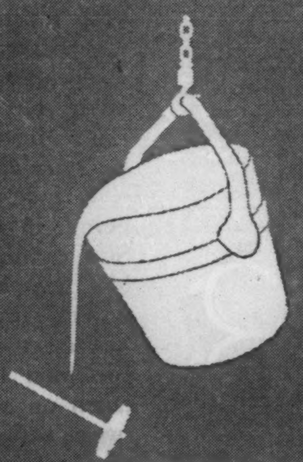
**Edited by Kenneth Rose**
Engineering Editor,
Metals and Alloys

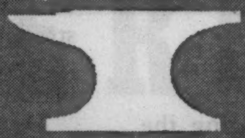
**Contributing Editors**
W. H. Boynton
Janet Briggs
W. H. Bruckner
J. C. Chaston
Frances Clark
Erich Fetz
B. W. Gonser
Max Hartenheim
B. Z. Kamich
Helen S. Knight
A. I. Krynitsky
V. A. Lamb
J. M. Noy
V. S. Polansky
M. Schrero
R. F. Seelig
B. H. Strom
H. F. Taylor











## MATERIALS and DESIGN

### Metals and Alloys

*Gray Iron as an Engineering Material* .............. 1372
*Copper and Its Alloys* .............................. 1374
*Air Hardenability of Steel* ......................... 1376
*Aluminum Alloy Additions and Corrosion* .......... 1378

### Nonmetallic Materials

*Wood-Filler Phenolic Plastic* ..................... 1380
*Properties of Wool Felt* ........................... 1380
*Tear Resistance in Elastomers* ..................... 1382

### General Product Design

*Aluminum Alloy Joining Methods* .................. 1384
*Steel Houses* ...................................... 1386
*Cost Analysis in Redesign* ......................... 1390
*Chromium Plated Piston Rings* .................... 1392

## METHODS and PROCESSES

### Melting and Casting

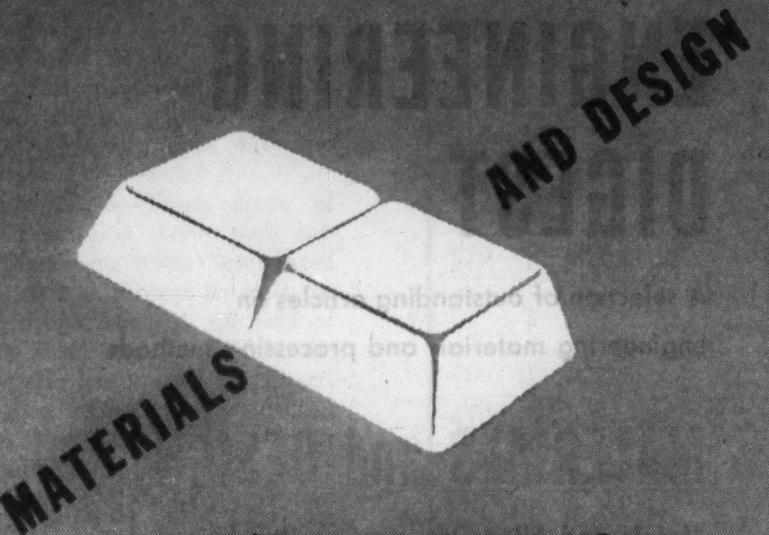
*Melting Metals in a Vacuum* ...................... 1394
*Planning Magnesium Casting* ...................... 1394
*Casting Steel Chain* ............................... 1396
*Power for Fast Melting* ............................ 1398
*Electric Rocking Resistor Furnace* ................ 1400
*Mullite Open Hearth Roof* ......................... 1402

### Fabrication and Treatment

*Reclaiming Zinc Chromate Primer* ................. 1404
*Production of Metal Powders* ..................... 1404
*Brazing* ............................................ 1406
*Forging of Steel* .................................. 1408
*Rotating Hearth Furnaces* ......................... 1410
*Types of Polishing Wheels* ........................ 1412
*Contour Forming Stainless Steel* ................. 1414
*Porous Chromium Plating* .......................... 1416
*Grinding With Diamond-Charged Mandrels* ....... 1418
*Forging on a Spot Welder* ......................... 1420
*Blue-Gray Chromium Plating* ...................... 1424
*Phosphate Coatings in Wire Drawing* ............. 1424
*Hyper Milling vs. High-Speed Milling* ............ 1426
*Spray Welding Pump Shafts* ....................... 1428

### Testing and Inspection

*Replica Test for Metal Finish* .................... 1430
*Optical Test Methods for Plastics* ............... 1430
*The Acoustic Strain Gage* ......................... 1432
*Long-Period Stress Deformation* .................. 1434



# METALS and ALLOYS

**Engineering properties and applications of carbon, alloy and stainless steels, irons and nonferrous metals and alloys. Selection and evaluation of metallic materials for engineering service. New alloys and modifications.**

## Gray Iron as an Engineering Material

*Condensed from "American Foundryman"*

It is generally possible to obtain gray iron castings with minimum tensile strength as high as 60,000 p.s.i. and in a few castings as high as 80,000 p.s.i. There exists a general relationship between composition and tensile strength indicated by a curve, the slope of which shows an increase of approximately 2,000 p.s.i. for each 0.1% decrease in carbon equivalent.

An iron with carbon equivalent of 4.3% has an approximate tensile strength of 25,000 p.s.i. The use of alloys and special inoculation treatments tends to elevate the curves without materially changing the slope.

Hardness of iron is not a true index of wear resistance, tensile strength, or toughness. Because cast iron is a heterogeneous material, its hardness should be measured by means of a 3000-kg. load on a hardened steel ball 10-mm. in diam. Microstructure specifications would be more reliable for general use than hardness.

Transverse strength can be a dangerous specification, since cast iron is very sensitive to cooling rate. A test bar may have a dense exterior and an open core, with the result that it may show remarkable transverse properties. Obviously a tensile specimen machined from this bar would have relatively low value because that part of the bar which is of greatest value has been lost in machining. It is possible to set up a wedge determination that will show the adaptability of any iron for the section involved.

A rough measure of percentage plastic and elastic deformation can be determined from stress-strain curves of the deflection resulting from transverse bend tests.

Modulus of rupture is higher because iron is denser on the surface and is less sensitive to notch effect in bending than in tension. It is an indication of the ratio of surface structure to core structure, and represents properties at and just beneath the surface.

Cast iron is an ideal material for applications involving principally compressive loading, since its compressive strength usually falls within three to five times the tensile strength.

The modulus of elasticity for cast iron usually ranges from 12 to 26,000,000 p.s.i. Generally, the low carbon irons have the high modulus and vice versa. Low modulus irons are best for resisting heat checks, absorbing vibration, and for some types of wear resistance, whereas high modulus irons are characterized by rigidity.

Shear strength is subject to considerable error, but the values can be assumed to range between 1-4/10 and 1-8/10 times the tensile strength of the iron.

Fatigue values of cast iron are quite high, being 43 to 58% of the tensile strength. Surface imperfections, notches, etc. are much less deleterious to cast iron fatigue and endurance limit than to other materials.

Impact is best measured on a Charpy specimen 1-1/10 in. diam. and 8 in. long taken on a Charpy machine with 6 in. between supports. Values will range from 20 to 80 ft. lb. and do not follow tensile strength. A tough, weak iron may show a relatively high value when compared to a brittle strong iron.

Damping capacity is one of the most important properties of iron, and permits low strength, high damping capacity cast iron to excel other materials with high physical properties and poor damping capacity.

Machinability of cast iron may be improved by avoiding a non-uniform structure that causes tool chatter.

Because of the graphite particles, or inclusions, cast iron has the ability to retain an oil film better than any other ferrous material. Wear resistant cast iron should have a structure of pearlite and graphite.

# GIANT SHEETS

## highly polished!

***. . . another***

## EASTERN STAINLESS feature!

Eastern Stainless craftsmen are all specialists in Stainless who take particular pride in their ability to furnish very large sheets finished precisely to your specifications.

If your requirements demand a brilliantly polished, mirror-like surface — one or both sides — you'll want the Eastern Stainless No. 7 Finish, one huge sheet of which is illustrated here. Or perhaps you require a somewhat less reflective sheet possessing a "satin" appearance. If so, you'll choose the Eastern Stainless No. 4 Finish. Then again, the job at hand may call for another of the seven popular sheet mill finishes Eastern Stainless offers to meet every need.

Come to Eastern for the answer whenever Stainless is the question. Eastern Stainless furnishes twelve standard and several special grades, all of highest quality, in a wide range of sizes and finishes. Consult the Eastern Stainless Technical Staff . . . you'll receive prompt, helpful service.

**FREE . . . NEW 96 PAGE CATALOG!**

Just what you want . . . an office-handy encyclopedia giving authentic information on modern applications of Stainless Steels in many great industries including your own. Contains much technical data compiled by Eastern Stainless specialists. Today—write for your *free* copy of the 1945 Eastern Stainless catalog—it'll be a valuable assistant in your daily work.

ES
EASTERN
STA
STE

*To meet your requirements, Eastern Stainless offers a wide range of sizes and finishes*

JMLco B-E1

# EASTERN STAINLESS

## STEEL CORPORATION

**BALTIMORE 3, MARYLAND**

***Distributors' stock available in most areas***

**CHICAGO • CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • PHILADELPHIA**

Irons with a high degree of plasticity have a remarkable resistance to heat shock in such parts as hot working dies. Where temperature is maintained at or near a fixed value, a carbide stabilizer such as chromium should be added.

—R. G. McElwee. *Am. Foundryman*, Vol. 7, Jan. 1945, pp. 12-16.

## Copper and Its Alloys

*Condensed from "Metallurgia"*

No fundamentally new methods have been developed among copper and its alloys, the trend being towards the improvement of established practice. By far the major portion of technical papers on the subject have been published in the United States.

Among outstanding trends are the use of larger low-frequency induction melting furnaces, more extended use of water-cooled molds, casting of strip ingots up to 1,000 lb. for cold rolling, or more for hot rolling, and much heavier fabrication equipment to cope with the larger sizes.

It is only a question of time before continuous casting becomes the standard method for copper alloys. Powder metallurgy has not made spectacular progress, but there has been continual expansion in the spheres of application. For metallic friction materials for brake and clutch linings in replacement of asbestos, powders have been compounded as follows: copper, 60 to 75%; tin and zinc powder, 5 to 10%; lead powder, 5 to 15%; graphite powder in small amounts and an abrasive powder such as silica or emery, 2 to 7%.

As to cast copper-base alloys, it is established that causes giving rise to severe unsoundness were the absorption of hydrogen evolved in the early stages of solidification, with oxygen also present either in the molten metal or picked up during pouring. Solubility of hydrogen in the copper-tin alloys is progressively lower as the copper content is reduced. The best method of removing hydrogen is by gas scavenging processes, such as bubbling nitrogen through the molten metal.

Yet, if a casting is completely degassed there is apt to be excessive shrinkage concentrated at certain positions; hence, there is failure in the pressure test. With metal of an intermediate gas content, such that the resultant density is 8.6 to 8.75, a disseminated type of porosity is obtained, which does not interfere with pressure tightness. Leaded gunmetals are found superior in this respect in that the lead particles tend to fill the small shrinkage cavities.

Phosphor bronzes of high phosphorus content, when made with moist green molding sand, have only moderate porosity and are favored for pressure castings.

Superior to the usual gun metal containing 12% Sn for high pressure castings is one containing 83 Cu, 7 Sn, 5 Pb, and 5% Zn. Nickel additions are also found favorable. The Bridgeport Brass Co. has discovered that 0.2% As benefits Muntz metal.

As to copper-manganese-nickel alloys, it has been shown that with a composition of

R & R
HYDROGEN
REDUCED
TUNGSTEN
METAL
POWDER
HIGHER PURITY
CONTROLLED MICRON SIZE
CARBIDE TOOLS AND CUTTERS
ORDNANCE
ELECTRONICS

**Geared for Faster Production in War or Post-War Industry**

***Ordnance . . Carbide Tools and Dies . . Electronics***

Hydrogen Reduced TUNGSTEN Metal Powder still plays a vitally important part in the vast war production program. The demand for the R & R Brand TUNGSTEN Metal Powder is chiefly due to its extreme high and uniform purity and the perfect control of particle size. These two distinguishing characteristics of this brand, have given it outstanding leadership in the industries, and other fields of service in which TUNGSTEN Metal Powder is so very essential.

Our XXX-A Hydrogen Reduced Tungsten Metal Powder, Purity 99.9+ per cent, has high acceptance in the Carbide Cutting Tool industry, and is a factor in quality production.

In Ordnance requirements our TUNGSTEN Metal Powder of higher purity has been used with unusual success and is a prime essential in the various types of war material.

In the Electronic field our Special XX Hydrogen Reduced TUNGSTEN Metal Powder, purity 99.9+ per cent is used with highest satisfaction, for wire and contact points and similar items.

Hydrogen Reduced TUNGSTEN Metal Powder has served war industries with marked success. When government demands were critical our company developed a plan that anticipated production requirements.

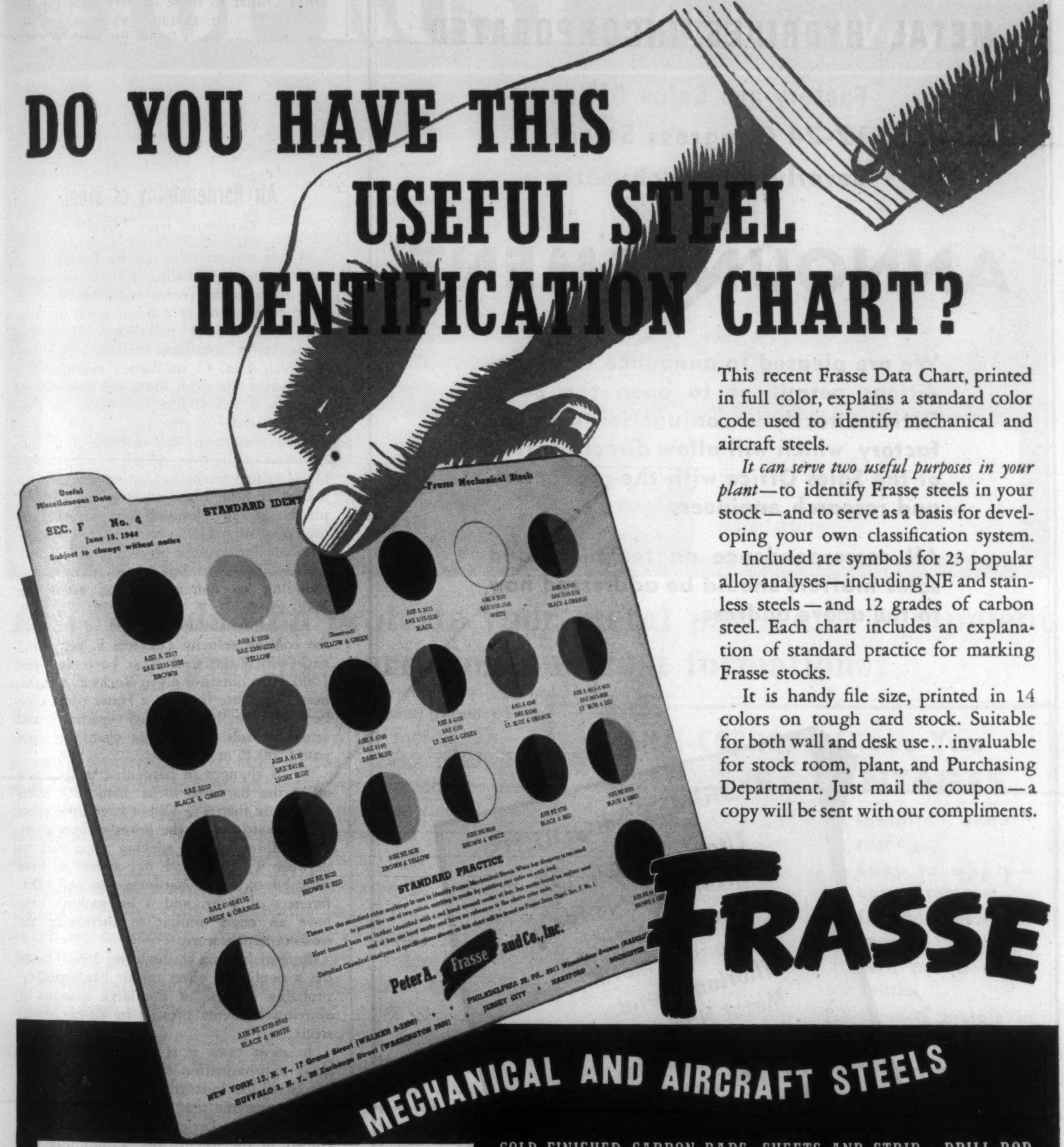
But when conversion to peace-time products begins manufacturers are assured of the same dependable service that has been our privilege to render in the past.

Hydrogen Reduced TUNGSTEN Metal Powder is produced by the Reduction and Refining Company according to any desired specification and particle size. Our brochure, "TUNGSTENOLOGY" which gives valuable data on TUNGSTEN Metal Powder and its compounds will be sent to inquirers on request.

R&R TUNGSTEN QUALITY POWDERS

REDUCTION and REFINING COMPANY
96 Roanoke Avenue, NEWARK, N. J.

# DO YOU HAVE THIS USEFUL STEEL IDENTIFICATION CHART?


Useful Miscellaneous Data
SEC. F No. 4
June 15, 1944
Subject to change without notice
STANDARD IDENT
Frasse Mechanical Steels
AISI A 2317 SAE 2315-2330 BROWN
AISI A 2330 SAE 2330-2335 YELLOW
(Reserved) YELLOW & GREEN
AISI A 3115 SAE 3115-3120 BLACK
WHITE
BLACK & ORANGE
SAE 3250 BLACK & GREEN
AISI A 4130 SAE X4130 LIGHT BLUE
AISI A 4140 SAE 4140 DARK BLUE
AISI A 4150 SAE 4150 LT. BLUE & GREEN
LT. BLUE & ORANGE
LT. BLUE & RED
SAE 6140-6150 GREEN & ORANGE
BROWN & RED
BROWN & YELLOW
BROWN & WHITE
BLACK & RED
BLACK & GREY
AISI NE 8735-8740 BLACK & WHITE
STANDARD PRACTICE
Peter A. Frasse and Co., Inc.
NEW YORK 13, N. Y., 17 Grand Street (WALKER 5-2200)
BUFFALO 3, N. Y., 20 Exchange Street (WASHINGTON 2020)
PHILADELPHIA 29, PA.
JERSEY CITY • HARTFORD • ROCHESTER

This recent Frasse Data Chart, printed in full color, explains a standard color code used to identify mechanical and aircraft steels.

*It can serve two useful purposes in your plant*—to identify Frasse steels in your stock—and to serve as a basis for developing your own classification system.

Included are symbols for 23 popular alloy analyses—including NE and stainless steels—and 12 grades of carbon steel. Each chart includes an explanation of standard practice for marking Frasse stocks.

It is handy file size, printed in 14 colors on tough card stock. Suitable for both wall and desk use... invaluable for stock room, plant, and Purchasing Department. Just mail the coupon—a copy will be sent with our compliments.

**FRASSE**

**MECHANICAL AND AIRCRAFT STEELS**

Peter A. FRASSE & Co., Inc.
Grand Street at Sixth Avenue
New York 13, N. Y.

Please send me a copy of your Frasse Data Chart, Section F, No. 4, showing your standard color code for steel identification.

*Name*____________________

*Firm*____________________

*Address*____________________

COLD FINISHED CARBON BARS, SHEETS AND STRIP • DRILL ROD
HOT ROLLED AND COLD DRAWN SAE, AISI & NE ALLOY BARS
STAINLESS STEEL SHEETS, STRIP, PLATES, BARS, WIRE, PIPE & TUBING
AIRCRAFT ALLOY BARS & TUBING • SEAMLESS PIPE & CONDENSER TUBING
SEAMLESS CARBON & ALLOY TUBING • WELDED CARBON & ALLOY TUBING

**PETER A. FRASSE & CO., INC.**

New York • Philadelphia • Buffalo • Jersey City • Hartford • Rochester • Syracuse • Baltimore

**METAL HYDRIDES INCORPORATED**

**Factory and Sales Office**
**12-24 Congress Street**
**Beverly, Massachusetts**

**ANNOUNCEMENT**

**We are pleased to announce that conditions permit us to open the Sales Office directly in conjunction with the factory, which will allow direct contact of the Sales Office with the production and research engineers.**

**All correspondence on technical and sales matters should be addressed now to the above address.**

**HYDRIMET PRODUCTS**

Titanium Hydride
Zirconium Hydride
Titanium Metal
Zirconium Metal
Thorium Metal
Metal Nitrides
Copper-Titanium
Copper-Zirconium
Beryllium-Nickel
Titanium-Nickel
Cobalt Alloys
Special Products
*Calcium Hydride

*A foolproof, convenient, easily transported source of hydrogen.

22 to 24% each of manganese and nickel, remainder copper, heat treatment may be applied to give hardness and strength properties similar to those of beryllium copper

—H. J. Miller. *Metallurgia*, Vol. 31
Dec. 1944, p. 83-8

## Air Hardenability of Steel

*Condensed from "Steel"*

A test to determine air hardenability of steel consists of drilling a 0.858-in. diam. hole through the center and tapping about 1 in. at each end of a 6-in. round by 6-in. long slug of 32% nickel-iron alloy. The hardenability specimen itself is 7 in. long, of which 4 in. (1 in. diam.) extends from the end of the 6-in. long slug and the remaining 3 in. (0.858 in. diam.) reaches into the center of the slug.

Two specimens are inserted, one into each end of the 6-in. round, and the assembly is heated to the hardening temperature, soaked at heat, removed from the furnace, placed on an elevated wire screen, and cooled in air. The specimens are then unscrewed, flats ground on two opposite sides, and hardnesses taken at locations corresponding to definite cooling rates past 1000 F.

Air hardenability is stated in terms of the cooling velocity (degrees F. per min.) with which the steel must be cooled past 1000 F. to obtain a given Rockwell-C hardness. This rate leads to a better correlation between the hardenability specimen and actual rounds and shapes than the rates past 1300 F. or 600 F.

Small changes in hardening temperature effect the hardness of air-hardening steels with more than 1% C, but have little effect on the hardness of the lower carbon steels. Small differences in soaking time, such as between ½ hr. and 1 hr., appear to have little effect on the hardness obtained. Differences of 1 hr. and 4 hr. soaking time have an effect similar to increasing the treating temperature.

Rate of heating through the critical range has a negligible effect on air hardenability, probably because of the large amount of alloying elements present in air-hardening steels.

In most cases it is possible to make a good approximation of the A/V value of a tool to be heat treated, as small holes, protrusions, and small recesses can generally be neglected. Large holes should be included in the calculation. Combining this value with the hardenability of the steel to be used, it is easy to estimate with accuracy the hardness to be obtained throughout the tool by air hardening.

In general, the variation in air hardenability of air-hardening steels is negligible from heat to heat for a given type composition. Therefore, the information in the table should lead to accurate estimates of the hardness to be expected in tools of various sizes and shapes made from these steels.

—C. B. Post, M. C. Fetzer & W. H. Fenstermacher.
*Steel*, Vol. 116, Mar. 5, 1945,
pp. 120-121, 132, 134, 136, 139.

# STOP RUST this New, Efficient Way—

In factories and machine-shops, Anti-Corrode is widely used to protect metals and metal products in storage, transit or in process of manufacture.

## Anti-Corrode film protects your metal parts and equipment ...prevents corrosion and rust formations

Anti-Corrode #100 is one of several new types of Cities Service protective coatings for metals. Designed to prevent corrosion of raw stocks, finished parts and completed machines—either in storage or in active service—Anti-Corrode adheres firmly to metal surfaces, displaces moisture and protects longer than similar materials now on the market.

Cities Service Anti-Corrode #100 may be applied by ordinary work-shop methods—spraying, dipping, brushing or rolling. Independent of metal quality, finish and irregularity of surface, the protective film is continuous and non-porous—does not break at sharp edges nor rupture on flat surfaces.

Cities Service Anti-Corrode #100 serves as a lubricant as well as a rust preventive and need not be removed from metal to be stamped, drawn, or otherwise formed. It can be removed simply with kerosene or any petroleum solvent.

### ANTI-CORRODE Gives You 10 BIG ADVANTAGES

1. **Adheres to all metal surfaces.**
2. **Impervious to humid atmospheres.**
3. **Water-repellent.**
4. **Resistant to sun rays.**
5. **Chemically inert to ferrous and non-ferrous metals.**
6. **Inhibits *"under"* rusting.**
7. **Easy to apply—easy to remove.**
8. **Lubricates as it conserves.**
9. **Will not become brittle.**
10. **Protects metals in service or storage.**

**There is a type of Cities Service Anti-Corrode for every need...for a single valuable tool or a million dollars worth of metal or equipment. Mail this coupon for a free demonstration.**

Cities Service Oil Company
Room 292
60 Wall Tower, New York 5, N. Y.

Gentlemen: Please contact me for a FREE demonstration of Anti-Corrode in our plant. (This offer limited to industrial users in Cities Service marketing areas East of the Rockies.)

Name ..........................................................
Position ..........................................................
Company ..........................................................
Address ..........................................................
City .................................... State ....................

CITIES SERVICE OILS
ONCE-ALWAYS

CITIES SERVICE OIL COMPANY
ARKANSAS FUEL OIL COMPANY

# ANTI-CORRODE
**SAFEGUARD FOR THE METAL WORKING INDUSTRIES**

Z-O-O-O-M UP TO way-below-zero from the boiling tropics in 5 minutes

Tiny precision parts take it because they're protected by NOX-RUST NO. 218-E

A combined rust-preventive and lubricant. Meets U. S. Army and Navy specifications. Ideal for aeronautical and similar precision instruments. Widely used wherever small parts are subjected to sharp temperature changes or temperature extremes.

NOX-RUST The Master RUST PREVENTIVE

For War or Peace

If rust and corrosion must be overcome, there's a NOX-RUST specific-purpose formula to achieve perfect results.

We invite you to state your rust-proofing needs so that we may send you a suitable compound as a

Free Sample

NOX-RUST Corporation

2455 S. HALSTED ST.,
CHICAGO 8, ILLINOIS

## Aluminum Alloy Additions and Corrosion

*Condensed from "Aluminium"*

Aluminum-magnesium-zinc alloys have a tendency to stress-corrosion, which increases with increasing sum of Mg+Zn, in which a change in the ratio Zn:Mg towards higher zinc contents exerts a particularly bad influence. As the alloy with 4.5 Zn and 3.5% Mg lies outside of the dangerous range of concentration, it was investigated what effect other additions have on stress-corrosion, tests being made on sheets 1 mm. thick.

Cerium brings about a deterioration of the stress-corrosion behavior, even in the presence of other stress-corrosion-delaying additions. The effect of iron and silicon is of no importance. Titanium improves stress-corrosion behavior.

Copper up to 0.5% and manganese up to 1%, singly and in combination, but in the latter case only to 0.25% Cu at simultaneously 0.5% Mn, increase the life as compared with the alloy without addition. Vanadium in amounts of 0.1% gives a considerable improvement, while higher contents (about 0.2%) have not the same effect.

In the presence of chromium-copper-manganese, the life of the alloy was increased for a few days by only 0.05%. However, when larger blocks are to be made, vanadium additions may cause segregation. Chromium produces a favorable effect in increasing the resistance to stress-corrosion.

Amounts below 0.1% when added alone have not the same favorable effect as equally large amounts of vanadium. However, 0.2% Cr is again better than 0.2% V. The best stress-corrosion resistance was found to be obtainable by combinations of chromium-copper-manganese, chromium-copper-manganese-vanadium, or chromium-copper-manganese-titanium. The most favorable contents were: 0.1-0.4 Cr, 0.1-0.6 Cu, 0.1-0.5 Mn, to 0.1 Ti and to 0.1% V. These alloys have an excellent stress-corrosion resistance even in the presence of 0.5 Fe and 0.5% Si.

As regards the mechanical properties, cerium, iron, and especially silicon, lower ultimate strength, elastic limit and particularly elongation. Titanium and vanadium bring only a slight improvement, while vanadium in the presence of chromium, copper and manganese does not offer any advantage. Chromium, copper and manganese, singly and in combination, increase ultimate strength and elastic limit of the additions-free alloy, with slightly decreasing elongation.

Other tests made on 100-mm. diam. rods confirmed the effect of the before-named additions on the stress-corrosion behavior as found with the 1-mm. sheets.

—H. G. Petri, G. Siebel & H. Vosskuhler, *Aluminium*, Vol. 26, Jan. 1944, pp. 2-10.

OXYGEN
FREE
HIGH
CONDUCTIVITY
COPPER

OFHC
REG. U.S. PAT. OFF.

- Hitherto the distribution of O.F.H.C. Copper has been restricted to certain special end uses such as electronics.
- O.F.H.C. Copper and a few special dilute alloys thereof are now available for most uses.

THE AMERICAN METAL COMPANY, LTD.
61 Broadway, New York, N. Y.

ST. JOE. LEAD CO.
Urgent!

*an appeal to consumers of*

# ST. JOE CHEMICAL LEAD

**St. Joe chemical lead which is the recognized "standard" for the manufacture of acid-resisting sheets, pipe etc. and which is also used extensively as protective sheathing for certain types of power cable, is not in sufficient supply to meet the current demand of these essential industries.**

**To alleviate this condition, the St. Joseph Lead Company urges everyone of its consumers to specify St. Joe chemical lead only where it is *impossible* to substitute another grade of lead for this vitally needed, natural copper-bearing metal.**

**This situation embarrasses us and inconveniences our valued customers. It is our sincere hope, however, that recent measures initiated by the Government Agencies will bring about an improvement in the situation. Until then, we ask your indulgence and cooperation.**

**TYPICAL ANALYSIS OF ST. JOE CHEMICAL LEAD**

| | |
|---|---|
| Silver | .0100% |
| Copper | .06 |
| Bismuth | Nil |
| Zinc | .0003 |
| Iron | .0003 |
| Arsenic-Antimony-Tin Combined | .0002 |
| Cadmium | .0003 |
| Cobalt & Nickel | .0046 |
| Lead by difference | 99.92+ |

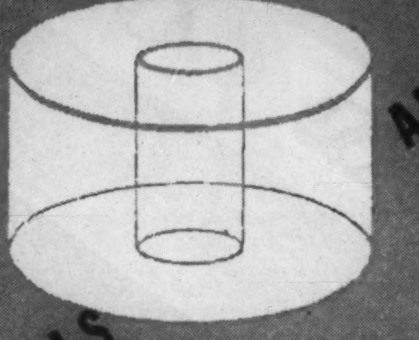
## ST. JOSEPH LEAD COMPANY

**250 PARK AVENUE · NEW YORK 17 · ELdorado 5-3200**

*Lead*
*Zinc*
*Zinc Oxide*
*Antimonial Lead*
*Antimony*
*Cadmium*

**THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES**

## MATERIALS AND DESIGN



# NONMETALLIC MATERIALS

Design-uses of plastics, plywood, fibre, glass, rubber, ceramics, etc. as engineering materials. Composite metal-nonmetal combinations. New types and forms of nonmetallic materials.

## Wood-Filler Phenolic Plastic

*Condensed from "The Engineers' Digest"*

Experiments to develop a new plastic-molding material consisting of 25% phenolic or cresolic resin maximum and coarse (sawdust) wood filler brought practical results. This material in the German specification is known at Type 41, and the maximum resin content has been specified at 28%.

The pelleting properties of the new material are not generally satisfactory. The bulk factor is a little below that of powders with chopped cellulose fillers, but twice as large as that of the general purpose material. Some difficulties have to be overcome when tools made for general purpose materials are used.

Shrinkage also is important when using existing tools. Measured on 5-mm. thick test pieces, it has been found to be rather above that of cellulose-filled standard powders, but a little below that of general purpose material. Where no special accuracy is required, no difficulties are anticipated in using existing tools.

The flow of the powder is of the greatest importance. It has been shown that the flow of the new material is generally better than that of cellulose-filled M.S.R. but not as good as that of soft, wood-filled powder or extra soft mineral-filled.

In testing the mechanical properties, it was found that the bending strength is a little below that of general purpose material and practically equal to the cellulose-filled. It is assumed that tensile and compression values are identical or near those of the M.S.R. cellulose-filled materials. Fatigue and endurance strength, hardness and resistance to wear are expected to be slightly below those of M.S.R.

Impact strength is also a little below, but the impact strength of the notched bar is considerably better, and moldings with uneven wall thickness especially are stronger against impact when made from the new material as compared with general purpose powder. In all cases where impact resistance is required and no water or humid conditions exist, application of the new material will result in improved quality of the products.

Results of heat tests are below those of other powders. No distortion is to be expected up to 90 C. (194 F.). The burning rate is practically identical with wood- or cellulose-filled material.

Surface resistance is only slightly below that of the general purpose material, and water resistance is below all standard powders. The new material, therefore, should not be applied where dimensional stability is required under humid conditions.

—R. Nitsche. *Kunstoffe*, Vol. 33, Apr. 1943, pp. 97-102; as abstracted in *Engineers' Digest* (British), Vol. 6, Jan. 1945, pp. 11-12.

## Properties of Wool Felt

*Condensed from "Mechanical Engineering"*

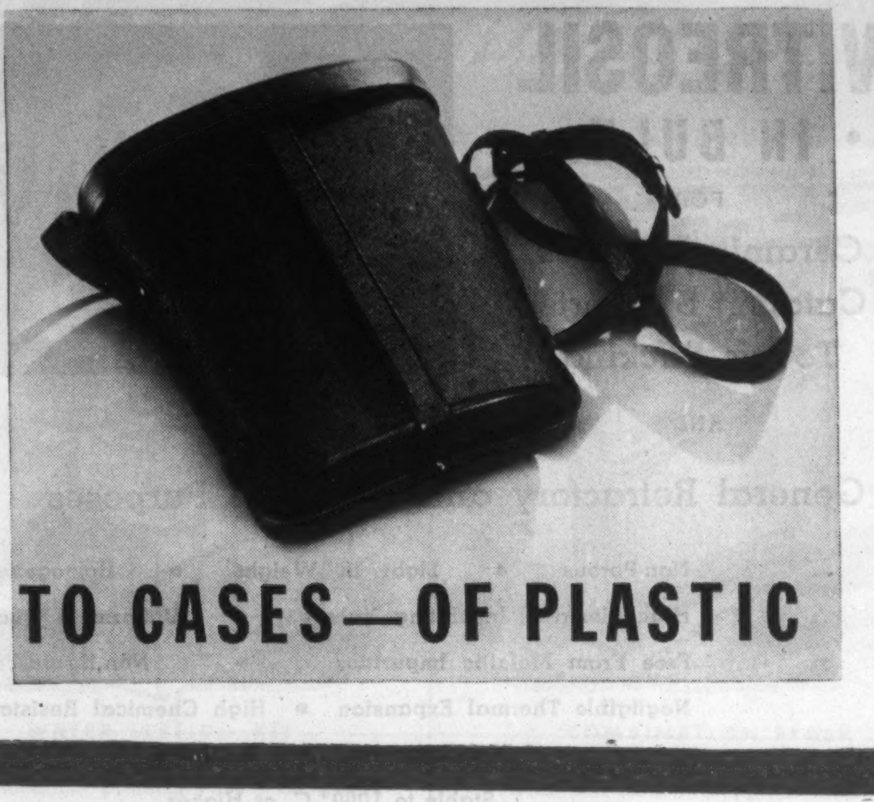
Wool felt is by definition "a fibrous material built up of interlocked wool fibers by mechanical and chemical action, moisture and heat." To attain specific properties in certain felts, non-felting vegetable and synthetic fibers are added in the blend with wool as the matrix. Percentages as low as 20% wool may be used.

Cotton combines to attain decreased felt density or to obviate voids in wool-base filter felts; rayon, silk and aralac to modify felt construction or surface texture. Kapoc-wool combinations as insulation felts have low thermal-conductance and high sound-absorption coefficient ratings.

Other materials going into felt manufacture are reprocessed wool, noils (noble and French), card waste (woolen and worsted), cotton from India or China, cotton merinos, hair (cattle and goat), ramie and jute, viscose and acetate rayon and vinyon.

There are 12 important mechanical functions fulfilled by felt: filtration, polishing, sealing, wicking, vibration isolation, sound absorption, thermal insulation, shock-absorbing, cushioning, padding, packaging, surfacing, spacing, and frictional.

The Society of Automotive Engineers has classified felts, and reports that: The wear resistance of felt is in direct proportion to density and fiber quality and in inverse proportion to applied load; the coefficient of friction is independent of density, but highly dependent on texture and smoothness of adjacent surfaces as well as viscosity of associated lubricating oils; the oil absorption capacity of the lower density felts is propor-



LET'S GET DOWN TO CASES—OF PLASTIC

● *Typical of the ingenuity of American industry in developing new products and improving old ones with plastics is the above-illustrated plastic binocular case which was produced by the Hood Rubber Company for Bausch & Lomb Optical Company*

Due to the vital importance of binoculars to the Armed Forces, it was absolutely essential that these instruments be carefully safeguarded against injury.

In the quest for the ideal material, eight different types were considered. Of these, only one successfully passed all the requirements for binocular cases. This was a laminated and molded plasticized vinyl reinforced with Durez phenolic-impregnated fabric and other materials.

This new case passes the accelerated-weathering (240-hr. test), salt-spray (100-hr. test), impact-resistance (4 ft., -50° F.), accelerated-warp (7 days, 160 to -10° F.), flexural-resistance (1½-in. radial bend), abrasion-resistance, and construction tests as set up by the U. S. Navy. Another interesting feature is the resistance to fungi and bacterial growth which this case possesses, to the extent that the binoculars themselves are immunized.

The versatility of Durez phenolic plastics has made their use almost universal throughout industry. Such properties as dimensional stability at temperature extremes, diversity of finishes, dielectric strength, and resistance to moisture, heat, acids and alkalies, render them invaluable to the imaginative design engineer.

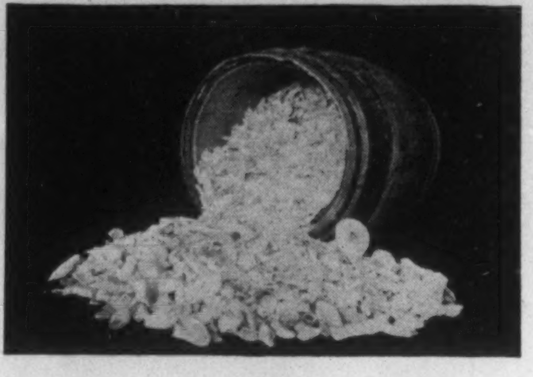
Perhaps you are searching for a material for some product which you intend to market in the post-victory era. If so, we suggest that you take advantage of the wealth of experience which Durez technicians have available for your benefit at all times. You are always assured of the complete cooperation of the Durez staff to help you solve plastic material problems. Durez Plastics & Chemicals, Inc., 275 Walck Road, North Tonawanda, N. Y.

DUREZ

PHENOLIC RESINS
- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

PLASTICS THAT FIT THE JOB

**VITREOSIL**
**• IN BULK •**
FOR
Ceramic Mixtures
Catalyst Supports
Tower Packing
AND
General Refractory and Technical Purposes



Non-Porous • Light in Weight • Homogeneous
High Electrical Insulating Values • Uniform in Quality
Free From Metallic Impurities • Non-Hygroscopic
Negligible Thermal Expansion • High Chemical Resistance
Non-Catalytic • Insoluble
Stable to 1000° C. or Higher
Prompt delivery from New York stock
WRITE FOR BULLETIN NO. 12

VITREOUS VITREOSIL REG'D TRADE MARK SILICA

THE THERMAL SYNDICATE, LTD.
12 EAST 46th STREET, NEW YORK 17, N. Y.

**BOSSERT *for Stampings!***

LARGE AND SMALL
•
HEAVY AND LIGHT METAL STAMPINGS
•
DEEP DRAWING
•
WELDING

Bossert maintains a staff of skilled engineers and designers and has solved many problems for its customers over the past thirty years. It has served the leading concerns in such industries as the automotive, refrigerator, electric washing and drying machines, electric power equipment, oil burning furnaces, water heater, tractor, concrete mixer, garment pressing machine, radio, rayon yarn, business machine, industrial filters, domestic sinks, railway supplies, gasoline curb pumps, airplanes, fire extinguisher, dairy, automotive accessories, and many others.

Our capacity for deep drawing is 54" diameter x 18" deep, or 39" x 72" x 12", in all metals, and up to 7/16" gauge. *OVER 200,000 SQUARE FEET OF FLOOR SPACE!*

ARMY E NAVY

THE BOSSERT COMPANY, INC.
UTICA, NEW YORK
*Established 1896*
NEW YORK CITY DETROIT

tionately greater than that of higher-density felts, as evidenced by a 200% greater retention capacity for S.A.E. F-15 than for S.A.E. F-1; the wicking rate is dependent on fiber quality, felt construction, density, and oil or fluid viscosity; thermal conductivity is notably low and decreases with decreased felt density; sound-absorption efficiency is dependent on variable factors of fiber blend, felt density and construction and air permeability.

—W. H. Lehmberg. *Mech. Engineering*, Vol. 67, Feb. 1945, pp. 93-99, 135.

## Tear Resistance in Elastomers

*Condensed from "India Rubber World"*

Although a common type of failure in rubber goods, tearing has been very difficult to evaluate. The A.S.T.M. has adopted tentatively a crescent-shaped test piece that makes possible the development of a stress gradient in the test machine, while a new test makes use of a 90° angle test section. The latter permits better evaluation of the stresses during tearing.

In these tests, four different elastomers were tested, and a study was made of the effects of heat aging at 100 C. on specimens tested at 25 C. Hevea (natural) rubber was compared with three synthetics, GR-S, Neoprene, and Hycar. Since commercial processing does not eliminate grain in the rubber, it was not removed in the test specimens. All values represent tearing with the grain.

Hevea stock showed a decrease in elongation at break from 570% to 260% as a result of 72 hr. aging at 100 C. The Buna S synthetic, GR-S, showed a decrease from 580% to 290%; Neoprene decreased from 450% to 300%, while Hycar went from 540% to 340%.

Increasing the test temperature with unaged stocks from the standard 25 C. to 100 C. changed the percentage elongation at break as follows: Hevea, 570% (at 25 C.) to 650%; GR-S, 580% to 320%; Neoprene, 450% to 250%; Hycar, 540% to 240%.

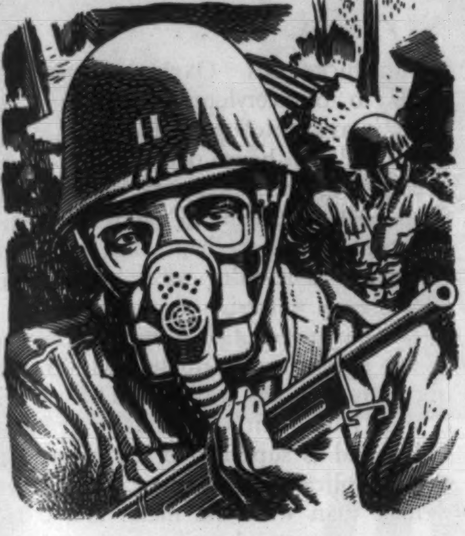
With the Hevea stock, the crescent specimen gave results about 37% higher than those for the angle specimen with the unaged stock. The former type seemed to be more influenced by stresses other than those involved in tearing. Values seemed to be dominated by the modulus and ultimate elongation of the material. With the angle tear specimen it was indicated that tear resistance is a complex function of tensile strength and ultimate elongation.

Synthetic elastomers tested showed less degradation of tensile strength and tear resistance than Hevea rubber with oven aging at 100 C. In the elevated temperature tests of original stocks, however, the natural rubber shows better retention of these properties.

Tensile strength dropped less than tear resistance with oven aging, while in the elevated temperature tests the effect is reversed. This may well be due to the influence of elongation on tear resistance, since in tests at elevated temperatures the drop in elongation is considerably less than the drop in tensile strength.

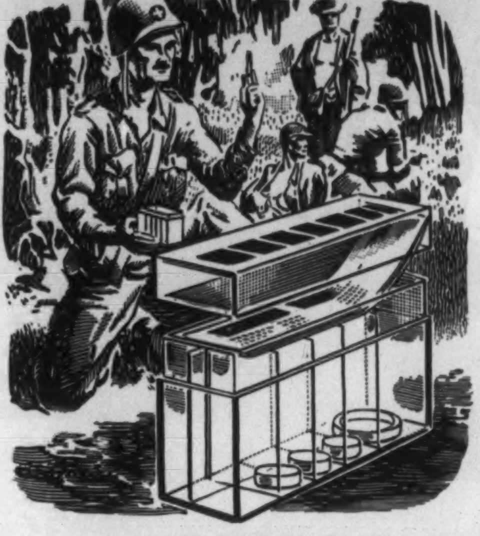
—Floyd L. Graves. *India Rubber World*, Vol. 111, Dec. 1944, pp. 305-308, 317.

# *Life-Savers in Lumarith**



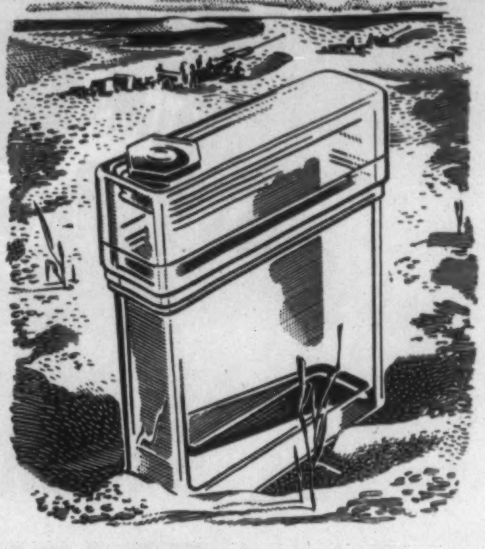
**GAS MASK PARTS**

The Lumarith* X components must fit precisely to insure vital protection. 1/64" lenses must curve to exact specifications—sealing discs in angle tube must be airtight. All the way through Lumarith X assures dimensional accuracy, toughness.



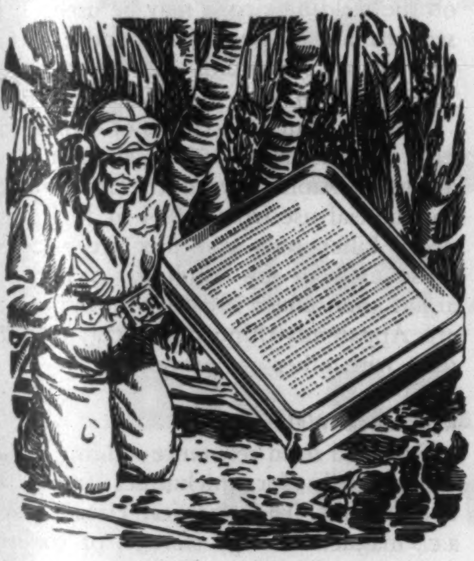
**WATER TESTING KIT**

This rugged Lumarith* E. C. (ethyl cellulose) container protects a set of chemicals used to test water supplies for advancing fighters. Color-reaction comparison specimens secured to the cover can be clearly seen yet protected against weather factors.



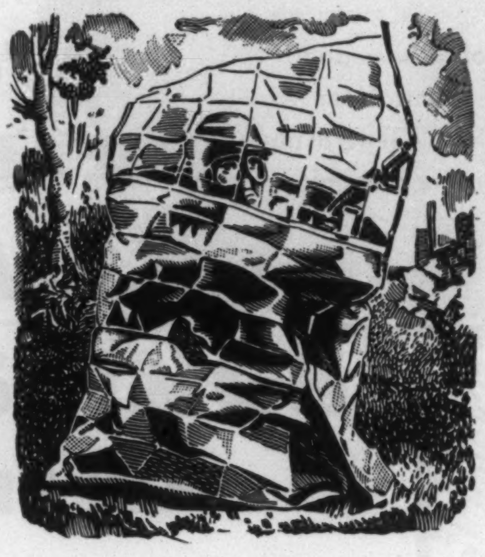
**COMBINATION FLASK**

First it serves as a container for emergency rations and medical supplies, then—when sealed with accompanying pressure-sensitive tape—as a flask for emergency water supply. It's made of tough, waterproof, non-shatterable Lumarith E.C.



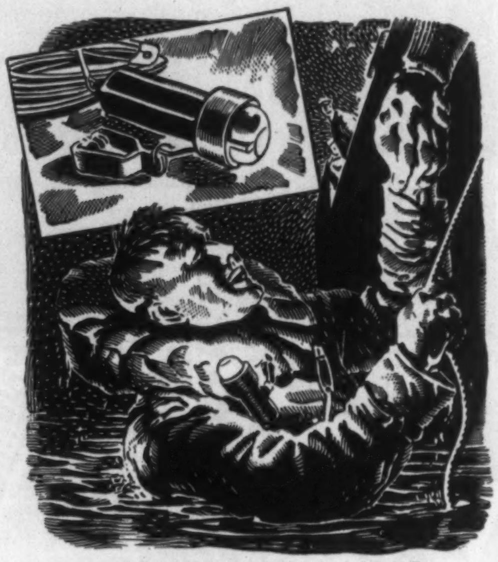
**EMERGENCY FISHING KIT**

Here's a real meal ticket for downed flyers awaiting rescue. Directions are permanently stamped in the container. The kit even includes a plastic lens for starting a fire. The material — Lumarith* C.A. — is water, mold and fungi proof, exceptionally tough.



**GAS CAPE**

Fabric, metal foil, cellophane and Lumarith foil effectively team up to protect GI Joe from poison gases. The cape is sealed with pressure-sensitive tape backed with Lumarith. For the container, Lumarith supplies waterproofness, toughness, fold strength.



**RESCUE SIGNAL LIGHT**

Signalling through darkness to rescue parties at sea, this Lumarith X encased battery lamp saves many a downed flyer's or seaman's life. It's tough, watertight, shockproof — qualities that have made Lumarith plastics outstanding.

IN **HUNDREDS** of applications—on land, at sea, and in the air—Lumarith meets new and exacting requirements for high impact strength, waterproofness and dimensional stability.

From spiral wound Lumarith containers for medical items, to Aero Quality Lumarith sheets for cockpit enclosures, a wide range of formulations score new highs in tensile strength, flexural capacity and surface resistance.

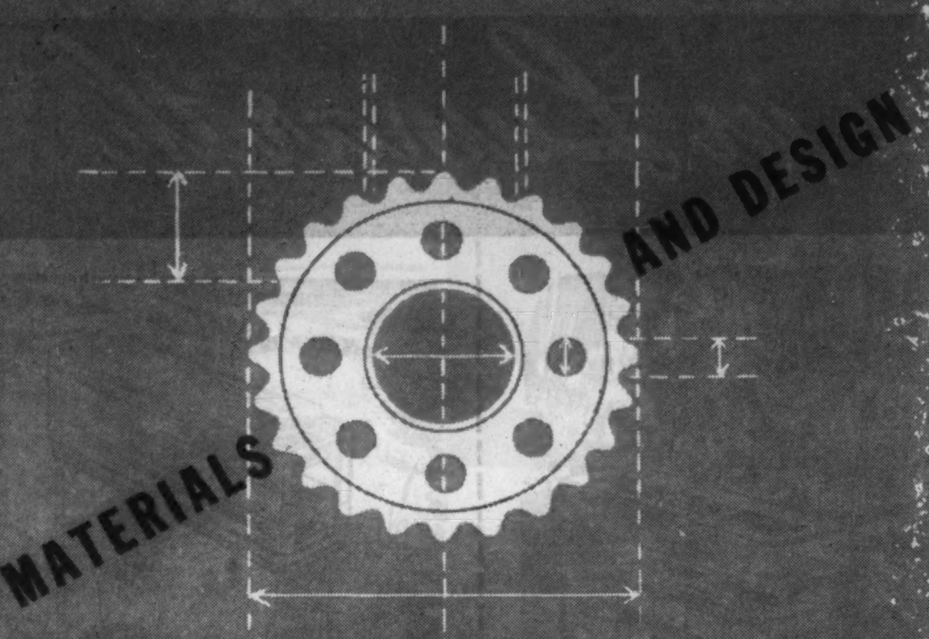
Lumarith* E. C. particularly stands out for high impact strength and dimensional stability even under extremes of humidity and temperature.

Our technical staff has helped to simplify any number of war production problems in plastics. Why not take advantage of this service? Celanese Plastics Corporation, a division of Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y.

*Reg. U. S. Pat. Off.

*A Celanese* Plastic*

**EXECUTIVES! Just published, 136 page manual entitled, "FABRICATING METHODS FOR LUMARITH* CELLULOID* AND SIMILAR THERMOPLASTIC MATERIALS." Write for complimentary copy on your company letterhead. Additional copies, $1.00 each.**



# GENERAL PRODUCT DESIGN

Selection, applications and design of parts made by various fabricating methods or made of special materials. Properties and uses of finishes and coatings. Design and materials for specific products or fields. General engineering design trends or principles.

## Aluminum Alloy Joining Methods

*Condensed from "Transactions" of the American Society of Mechanical Engineers*

Riveting of aluminum alloys may be done with aluminum alloy or steel rivets. Five main types of aluminum alloy rivets are used: 2S (only in non-structural joints of low strength aluminum alloy); A17S (most widely used): 17ST (most widely used in aircraft); 24ST (strongest; use largely confined to aircraft); and 53ST61 (most used in marine construction). 24ST and, generally, 17ST are heat treated just before use.

Reamed rivet holes are preferred. Up to 1/16-in. sheet, it is common to prepare for flush riveting by dimpling instead of machine countersinking. By heating to 400 F., 53ST61 can be driven "warm." Steel rivets require less pressure than aluminum rivets, but have the disadvantages of added weight and less resistance to corrosion.

In general, rivets are not well suited for transmission of direct tensile loads, and represent a point of weakness in fatigue failures. Hot driven steel rivets reduce the fatigue strength more than cold driven steel rivets, or than hot or cold driven aluminum alloy rivets.

Gas welding may be used for 0.025 to 1 in. thicknesses. Oxyhydrogen is about equal to oxyacetylene. Automatic equipment is available up to ⅛ in. Aluminum copper alloys have poor weldability and generally attain their maximum strength from heat treatment, so gas welding lowers the strength and perhaps also the corrosion resistance. The filler wire depends on the alloy being welded.

The amount of distortion and the changes in the parent metal are less with arc welding than with gas welding. The carbon arc is widely used, either manually or automatically, and is superior to the metal arc for many applications. Thinner sections can be welded than with the metal arc, 0.040 to ⅜ in., and no preheat is necessary. A filler rod with a thin flux is used.

Increased speed and substantially less distortion are obtained with automatic welding from 3/16 to ¾ in. With the metal arc, d.c. or a.c. welding equipment of the type that superimposes a high frequency current on the welding circuit may be used. If thin sections are welded, the soundness is improved by preheating to 400 to 600 F. Sizes 0.081-in. and thicker may be welded.

Heavily coated electrodes of commercially pure aluminum or 5% Si aluminum alloy are used. Atomic hydrogen (manual) is in commercial use from 0.064 to ⅜ in. thickness. Filler rods and flux are similar to those used in gas welding. A helium or argon atmosphere is used with the tungsten arc. Apparently thinner sizes may be welded than with other arc processes.

### Resistance Welding

Spot and seam resistance welding are used commercially for thicknesses from 0.010 to 5/32 in. The electrical circuit may be a.c., magnetic energy storage, or condenser energy storage. Three factors are much more important with aluminum alloys than with other metals: electrode shape (for proper current and pressure distribution); electrode cooling; and preparation of the metal to be welded.

Brazing (furnace, torch, dip) generally costs less than gas or arc welding, and gives neater joints with less finishing required. Material too thin to be welded can be brazed (furnace brazing may be used for thicknesses from 0.006 to ½ in.). Lap joints are generally used rather than butt or scarf. Commercially pure aluminum and aluminum-manganese alloys are the only wrought non-heat-treatable alloys for which commercial brazing has been developed.

The strength of torch-brazed joints is about equal to gas welded joints, while the resistance to corrosion is comparable to welded joints of the same alloy. In torch brazing, oxyhydrogen and oxyacetylene give better results than oxynatural gas. In dip brazing, it is not necessary to apply brazing flux.

ACCURACY!
—EXACTING PRECISION AT 60 POINTS ON THIS ZINC ALLOY DIE CASTING
IMPACT!
—JUST ONE OF THE MECHANICAL PROPER IN WHICH ZINC ALLOY DIE CASTINGS E
SPEED!
—ONE HOUR'S PRODUCTION OF DIE CASTINGS ON A HIGH SPE
.015"
—THE CASTABILITY OF ZINC ALLOYS PERMITS THIN SECTION DIE CASTINGS
ECONOMY!
—ANOTHER ZINC ALLOY DIE CASTING CUTS COST AND IMPROVES APPEARANCE
FINISHABILITY!
—ZINC ALLOY DIE CASTINGS CAN TAKE ALMOST ANY KNOWN TYPE OF FINISH
DUCTILITY!
—2 ZINC ALLOY DIE CASTINGS ASSEMBLED BY "CURLING"—AT THE RATE OF 375 AN HOUR!
COMPLEXITY!
—59% LESS LABOR REQUIRED THRU THE USE OF 3 ZINC ALLOY DIE CASTINGS IN THIS DRILL
716°F.
—LOW MELTING POINT OF ZINC ALLOY HAS ENABLED THIS DIE TO PRODUCE OVER 2,000,000 DIE CASTINGS
SHORT CUTS!
—MACHINING PROBLEMS SIMPLIFIED WITH ZINC ALLOY DIE CASTINGS

10 REASONS WHY*

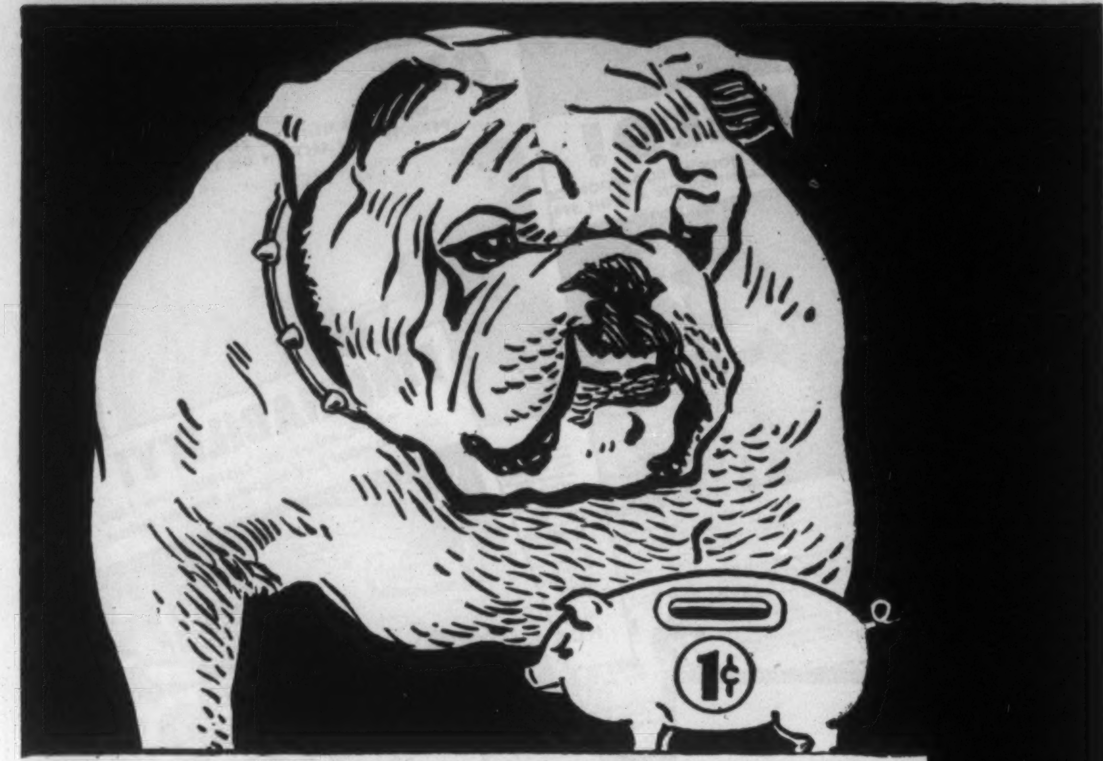
YOU WILL USE
ZINC ALLOY
DIE CASTINGS
AFTER THE WAR

*A full set of these advertisements will be sent on request.

ZINC
FOR DIE CASTING ALLOYS

THE NEW JERSEY ZINC COMPANY
160 Front Street, New York 7, New York

The Research was done, the Alloys were developed, and most Die Castings are specified with
HORSE HEAD SPECIAL (99.99+% Uniform Quality) ZINC



You'll have to
WATCH YOUR PENNIES
in the PEACETIME COMPETITION

With the coming of peace and a return to the American way of producing goods at a profit in highly competitive consumer markets you'll *have* to be certain that every step from initial blueprint and tool design, through the machining, stamping and assembly line, up to packaging and delivery is planned and executed with utmost efficiency and with the minimum of cost.

In the production of war munitions Oiljak has maintained an enviable record of production of intricate parts and on time deliveries, in accordance with strict Government inspection—and has actually reduced the estimated and approved cost, thus saving the Government considerable sums, by skillful planning and supervision of the work. These same skills in metal manufacturing, improving designs and reducing costs are available to manufacturers as they convert to peacetime merchandise. It may transmit your penny savings into dollar profits to confer with us on any metal manufacturing problem.

Machining • Stamping • Welding • Plating • Finishing • Assembling

**The OILJAK Mfg. Co., Inc.**

ARMY E NAVY

MONTCLAIR, N. J.
METAL MANUFACTURERS

THE JOB COMPLETE . . .
*from blueprint to finished product*

While commercial experience is quite limited, possible applications include finned tubing, radiators and heat exchangers. Preheating at 900 to 1000 F. gives somewhat smoother joints and increases the speed.

Soldering is little used due to inferior flux flow, ready formation of the aluminum oxide film and possible electrochemical interaction. Ordinary electric or gas-fired soldering irons can be used as can furnaces, induction or resistance heating. It is also possible to dip prefluxed parts into molten solder baths. All kinds of fluxes and solders are used, but the most common solder is 50 to 75% Sn, balance zinc.

17S and 24S should not be soldered, as there is a rapid intergranular penetration of the molten solder. Generally, soldered joints will last indefinitely if used indoors, but there is not much chance for successful use on unprotected parts immersed in water or exposed to moisture or saline environments.

Resin bonding involves a complete bonding of the faying surfaces with synthetic or natural rubber, or a combination of synthetic resins. Generally, the bonding requires heat and pressure (250 to 450 F. for thermoplastic cements; 200 to 500 F. for thermosetting plastics and vulcanizable cements). The strength per unit area is relatively low, so the design must provide for large joints.

Resin bonding is ideal for large lap joints. The resistance of the bonds to moisture will probably be improved in the future.

—E. C. Hartman, G. O. Hoglund & M. A. Miller. *Trans. of the ASME*, Vol. 67, Jan. 1945, pp. 1-21.

## Steel Houses

*Condensed from "Iron and Steel"*

A house of unit steel construction that can be rapidly erected by unskilled labor has been proposed. The firm claims that the number of man-hours required per house is lower than for any other permanent building system yet devised.

The frames are supported on continuous concrete walls about 1 ft. wide. The ground floor is suspended on steel beams in the same way as the first floor. The steel frames extend continuously to the full height of the house. Each consists of two main verticals connected across by a number of horizontals.

The frames are of two nominal widths: Single frames, 3 ft. 2 in., and double frames, 4 ft. 6 in. Both verticals and horizontals are cold rolled from steel strip. An overall frame-thickness of 3½ in. is maintained throughout.

Horizontals are joggled inwards at their ends to fit between the inwardly directed flanges of the verticals, to which they are rigidly fixed by spot welding. These stay the verticals and provide backing support to the sheets of external cladding and internal lining. In this way the number of house plans that can be built up with the standard frames is unlimited.

Along the tops of all beams, strips of fibre-board, or the equivalent, are laid to

*(Continued on page 1390)*

# CORROSION RESISTANCE

## FRONTIER ALLOY "40-E"

**A HIGH STRENGTH**

**ALUMINUM** *Alloy*

**THAT NEEDS NO HEAT TREATMENT**

**The ALLOY that has ALL 6**

**The metallurgical formula of Frontier "40-E" Alloy overcomes the corrosion danger commonly encountered in certain types of aluminum alloy containing zinc. Frontier "40-E" is highly resistant to the action of corrosive atmospheres and liquids. What's more this desirable corrosion resistance is applicable to the metal under stress (stress corrosion) as well as to unstressed sections. Here, definitely, is significant development in the field of aluminum alloys.**

**ENGINEERING DATA ON REQUEST**

The Frontier Alloy Data Book brings pertinent engineering and metallurgical facts on the physical properties of "40-E". In writing for your free copy, please state company name, your title, and address.

Licensing franchises now available in certain areas to meet the increasing demand for Frontier "40-E" Alloy. Details on request.

1. **Shock Resistance**—Tests have proved its exceptional ability to withstand explosive shock and standard impact shock.
2. **Corrosion Resistance**—Excellent, not only in standard corrosion tests but also under stress.
3. **High Yield Strength**—A dominant factor where distortion or misalignment of parts would make the assembly inoperable.
4. **Machineability**—Far superior to the usual sand cast aluminum alloys and machined parts have a high lustre.
5. **Pressure Tightness**—The fine grain of the alloy enables it to withstand high pressures.
6. **No Heat Treatment**—Physical properties are obtained by natural aging at room temperatures.

**Specifications**—Army-Navy Aeronautical Spec. AN-A-17; U. S. Navy Bureau of Ships Spec. 46A-1 (INT), Class 1. A. S. T. M. Spec. B26-42T, Alloy ZG-41, S. A. E. 310.

**Typical Physical Properties**—tensile strength, 35,000 psi.; yield strength, 25,000 psi.; elongation, 5% in 2".

**FRONTIER BRONZE CORPORATION**
**4874 PACKARD ROAD**
**NIAGARA FALLS, NEW YORK**

**Equipped to Serve the 76% with ACME ALUMINUM CASTINGS!**

**76%** of the plants answering a recent materials survey said they use aluminum in some form in their normal products—and a large percentage of them indicated they expect to increase their use of this light weight, corrosion resistant metal.

Since Acme was founded over a quarter of a century ago, it has steadily expanded its service to meet the advancing needs of the metal-working industry.

Today Acme facilities for the production of aluminum castings by the *permanent mold process* represent the very latest developments in technique and equipment. Acme assumes the responsibility for all steps in production. Acme makes the pattern; Acme makes the mold; Acme pours the metal. You can rely upon Acme Permanent Mold Castings for accuracy, for uniformity, for outstanding quality.

The advantages offered by Acme Permanent Mold Aluminum Castings may help you to lower costs; to improve production. Our engineers will be glad to submit recommendations.

**GET THE COMPLETE ACME STORY** Send for 44-page, fully illustrated book, showing how Acme is organized and equipped to supply your castings needs and to render complete service to the metal-working industry.

ACME
*Aluminum Alloys, Inc.*
Formerly Acme Pattern & Tool Co., Inc.
DAYTON 3, OHIO
PATTERNS · TOOLS · ALUMINUM CASTINGS · ENGINEERING

provide a sound-insulation cushion, preventing the travel of sound from room to room throughout the structural framework.

The webs are stiffened by plates at suitable intervals, and cleats are provided at the lower flange for the attachment of cover strips supporting the ceiling boards. Beams are designed to carry a specified load at spacing of 3 ft. 2 in. on a maximum span of 12 ft. 8 in.

### Rustproofing

With thin steel sections, the question of rustproofing is important. The steel work for the prototype houses was painted at the works with rust-inhibiting and waterproof paints. Smaller details are galvanized.

The roof consists of slabs of lightweight cellular concrete in standard grid sizes, 2½ in. thick, reinforced with steel mesh and finished in bituminous roofing material. A roof in zinc sheeting, insulated with fibreboard or equivalent, is a possible alternative.

The wall proper consists of lightweight cellular concrete slabs, 2½ in. thick by 3 ft. 2 in. long by about 1 ft. 6 in. deep. These are built up on each side, close to, but not in contact with, the steel frames, providing efficient fire protection and insulation against sound. The slabs are jointed with plastic cement.

The external cladding can be of asbestos cement, brick or enamelled steel sheet, while the internal linings are of insulating plywood, fibre-board, or glazed asbestos. Ceilings are of cellular plywood or fibreboard. The floors are of stiffened plywood panels laid on sound insulation strips on the beams. The insulation is of slag wool or Isoflex fibre-boards.

It is claimed that the man-hours required are 1000 to 1200 for an 850 super ft. house at an average cost of 18/6 per ft. super, including all usual work on the site.

—*Iron and Steel*, Vol. 18, Jan. 1945, pp. 3-5.

## Cost Analysis in Redesign

*Condensed from "Die Casting"*

The proper approach to cost analysis should be based on a per unit breakdown. Often a great disparity between two preliminary cost figures for two different methods of fabrication may prove to be more apparent than real.

Analyses of three parts of a mercury in glass industrial thermometer for use in the food industry are discussed. The parts and the methods of fabrication are: (1) Sanitary elbow—sand cast 18% Cr, 8% Ni; sand cast nickel bronze; sand cast brass (chromium plated); sand cast aluminum (chromium plated); die cast aluminum (chromium plated); (2) 7-in. case—sand cast aluminum; die cast aluminum; and (3) cap with loop—die cast aluminum (chromium plated); fabricated brass (chromium plated).

Prices were obtained from suppliers on the basis of preliminary drawings. Shop estimates on machining and finishing were made. The combination of these figures gave a lump sum for the cost of tooling

CORNING REG. U.S. PAT. OFF. MADE IN U.S.A.

GLASS

*from* SIGNAL LENSES *to* PIPE LINES

From Corning's roaring glass furnaces comes the glass that is used in the signal lenses that make air and rail travel safer . . . and in the miles of glass pipe lines that help to keep production flowing in so many industries.

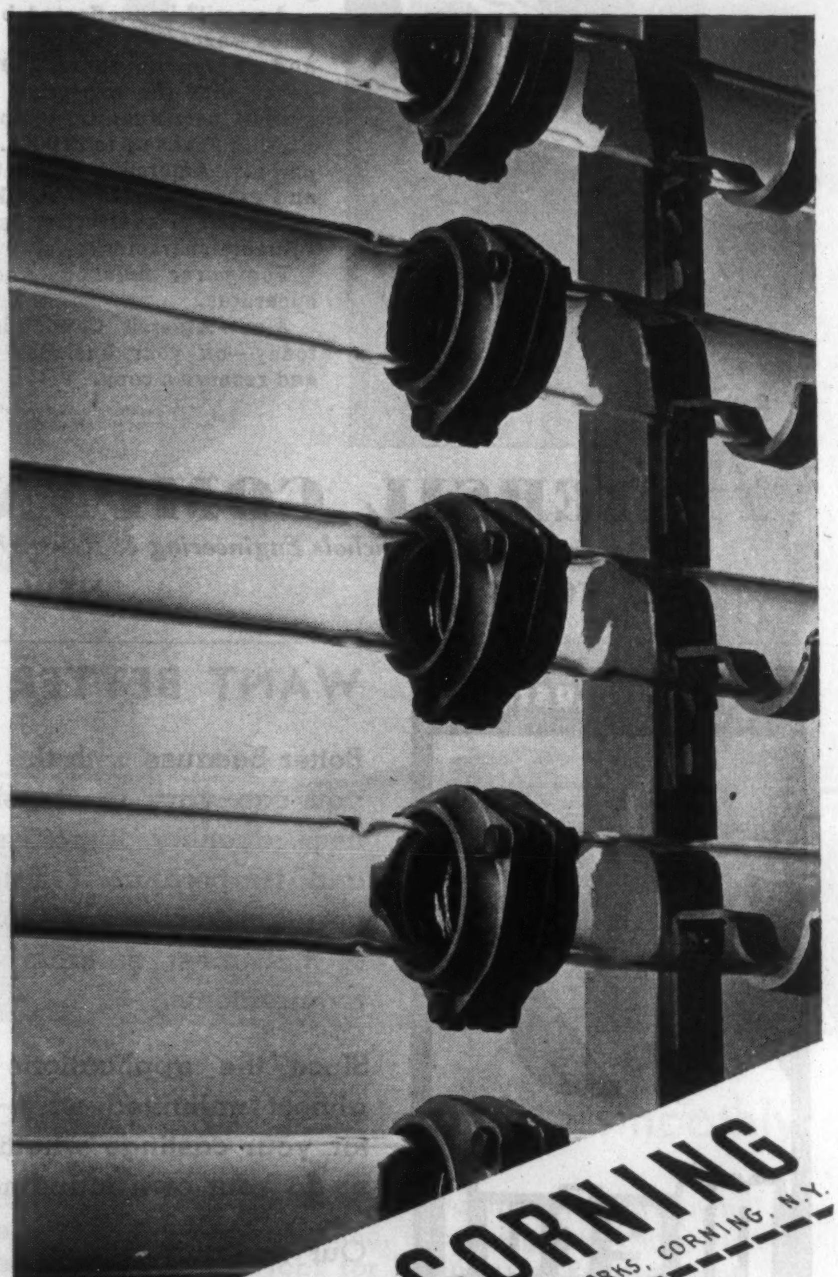
Working in cooperation with the Signal Section of the AAR and the U.S. Bureau of Standards, Corning technicians have created the color standards and specifications to which all railroad signal glassware is produced. Millions of lenses, in all standardized sizes and colors, have been produced by Corning.

From Corning Laboratories also came PYREX Brand Glass used in the pipelines of chemical, food and drug industries. PYREX Brand Glass is highly resistant to all acids except HF, free from corrosion, and highly resistant to thermal shock. It has solved many of the major conveying problems of industries where freedom from contamination, heavy metal pick-up and corrosion resistance are so important.

Only Corning has the experience, the research and production facilities to create and produce all of the many types of glassware used in these and in other widely different applications.

Perhaps you have a problem in materials that can be solved only through the use of glass. Corning Engineers will gladly recommend the particular glass from the thousands of formulae their research has developed. Corning's production facilities assure you of economical production of quality glassware. Write to Industrial Sales Department MA-5 Corning Glass Works, Corning, N. Y.

**CORNING GLASS WORKS**
**CORNING, NEW YORK**



CORNING means Research in Glass

INDUSTRIAL GLASS by CORNING

"PYREX" and "CORNING" ARE REGISTERED TRADE-MARKS AND INDICATE MANUFACTURE BY CORNING GLASS WORKS, CORNING, N.Y.

**INDUSTRIAL SALES DEPT., MA-5**
**Corning Glass Works, Corning, New York**

**Please send me a copy of your Bulletin 842 — "*Industrial Glass by Corning.*"**

**Name**.................................................. **Title**..............................
**Firm**..........................................................................................
**Street**........................................................................................
**City and State**.........................................................................

**Amersil***

(TRADE NAME REGISTERED)

**ASSURES FINISHED PRODUCT PURITY**

**Because Amersil* (fused silica) is 99.8% pure silicon dioxide, it cannot contaminate acids or other chemicals handled in piping, cooling sections, absorbers, etc., made of it and absolute purity of the finished product is assured.**

**Amersil* is unaffected by any of the mineral acids—except hydroflouric (at all temperatures), and phosphoric above 270°F.—or by the halogens, with the exception of flourine. It withstands, permanently, temperatures up to 2100° F., with peaks up to 2700°F. permissible for short periods. Amersil's ability to withstand sudden and extreme thermal shocks without noticeable expansion or contraction is another of its many valuable characteristics.**

**For purer finished products, use Amersil* apparatus.**

**A new Amersil* Catalog is on the press. Write today—on your business letterhead, please—and reserve a copy.**

*The registered trade name of the only American manufacturer of a complete line of Fused silica products.

**AMERSIL COMPANY Inc.**

*A subsidiary of Nichols Engineering & Research Corp.*

**60 WALL TOWER** **NEW YORK 5, N. Y.**

**For Your Castings**

**Z Metal**

DUCTILITY
HARDNESS STRENGTH

- Maximum strength with minimum weight
- Accurate casts
- High machinability
- Low finishing costs
- Selective hardenability
- Maximum density with minimum porosity
- Corrosion resistant

**WANT BETTER CASTINGS?**

**Better because with the Z-Metal treatment, you can vary the tensile strength, hardness, ductility, impact strength, corrosion and temperature resistance. With such variables under your control, you are sure of the most suitable casting for your requirements.**

**Since the applications for Z-Metal are almost unlimited why not investigate it for your castings whether you buy them or do your own founding?**

**Our metallurgists will be glad to study your problem and suggest the proper treatment.**

Z METALS

**FERROUS METALS CORPORATION**

**36 W. 44th St., . . . . . New York 18, N. Y.**

5-FMC-1

and a unit manufacturing cost including material, labor, and overhead.

Interest was ignored as it was a negligible factor. Tool maintenance was also omitted, as it would be done in the shop foundry and would be about the same for the various types of construction. Then, the average unit cost as a function of the total production was set up for each method of fabrication.

Utility, cost and appearance of each method of fabrication were discussed at a conference of sales, engineering, manufacturing and management. Sand cast aluminum was chosen for the sanitary elbow as the break-even point with die cast aluminum was 5200 pieces, which would take some time to attain. If a larger production were decided upon, it would be easy to convert to die cast aluminum. All other methods were considerably more expensive.

Die cast aluminum was chosen for the 7-in. case, as the break-even point would be reached within a few months and the eventual saving would be $0.31 per piece after the tools were completely amortized. In addition, it was believed that the die cast trademark would be more attractive than the sand cast.

Fabricated brass was chosen for the third item as the tools were available and the break even point with die cast aluminum would not be reached for some time.

—C. L. Wilder. *Die Casting*, Vol. 3, Jan. 1945, pp. 34-39.

## Chromium Plated Piston Rings

*Condensed from "Metal Finishing"*

Increased life of aircraft engine cylinders and rings is obtained by the use of porous chromium plated rings. The chromium plated rings are used only in the top groove on the piston. The other rings are plain gray iron.

Data on engine tests show that the use of porous chromium plated rings reduces the cylinder wear to one-third of that obtained with unplated rings. The wear on the rings themselves is about one-fifth that of unplated rings.

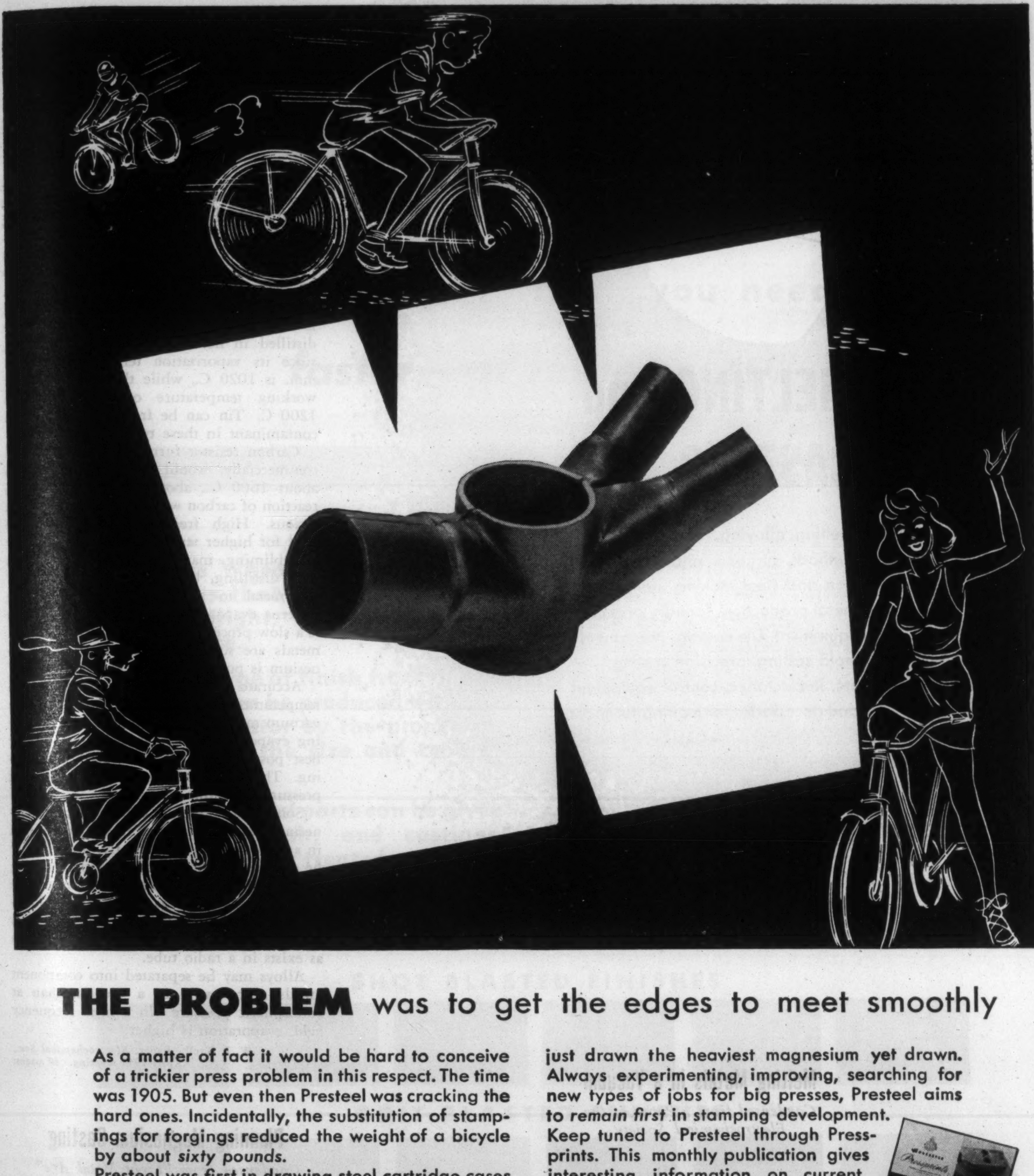
The porosity in the chromium plate permits the ring to seat quickly without much wear, resulting in two perfectly mated surfaces. The thickness of chromium applied is from 0.004 to 0.006 in., and the depth of porosity is from 0.0007 to 0.0015 in.

For plating, the rings are assembled in stacks of 100 on an arbor. The gaps between the ring joints are filled with lead to prevent uneven plating next to the gaps. The rings are then honed to a fine surface. The arbor assembly is carefully centered inside a cylindrical anode, to insure uniform plate thickness.

After plating, the rings are separated and a radius ground on the outside edge. They are then inspected.

The plating solution is kept free of sludge, the fixtures are kept clean, and even the air in the room is filtered, in order to prevent roughness of the plate due to suspended solid particles in the plating solution.

—T. C. Jarrett & R. D. Guerke: *Metal Finishing*, Vol. 42, Dec. 1944, pp. 732-735.

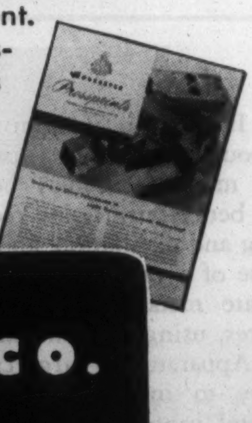


**THE PROBLEM** was to get the edges to meet smoothly

As a matter of fact it would be hard to conceive of a trickier press problem in this respect. The time was 1905. But even then Presteel was cracking the hard ones. Incidentally, the substitution of stampings for forgings reduced the weight of a bicycle by about *sixty pounds*.

Presteel was *first* in drawing steel cartridge cases (1919); *first* to draw false ogives (windshields) for shells (1930); *first* in "ironing" aluminum, and has just drawn the heaviest magnesium yet drawn. Always experimenting, improving, searching for new types of jobs for big presses, Presteel aims to *remain first* in stamping development.

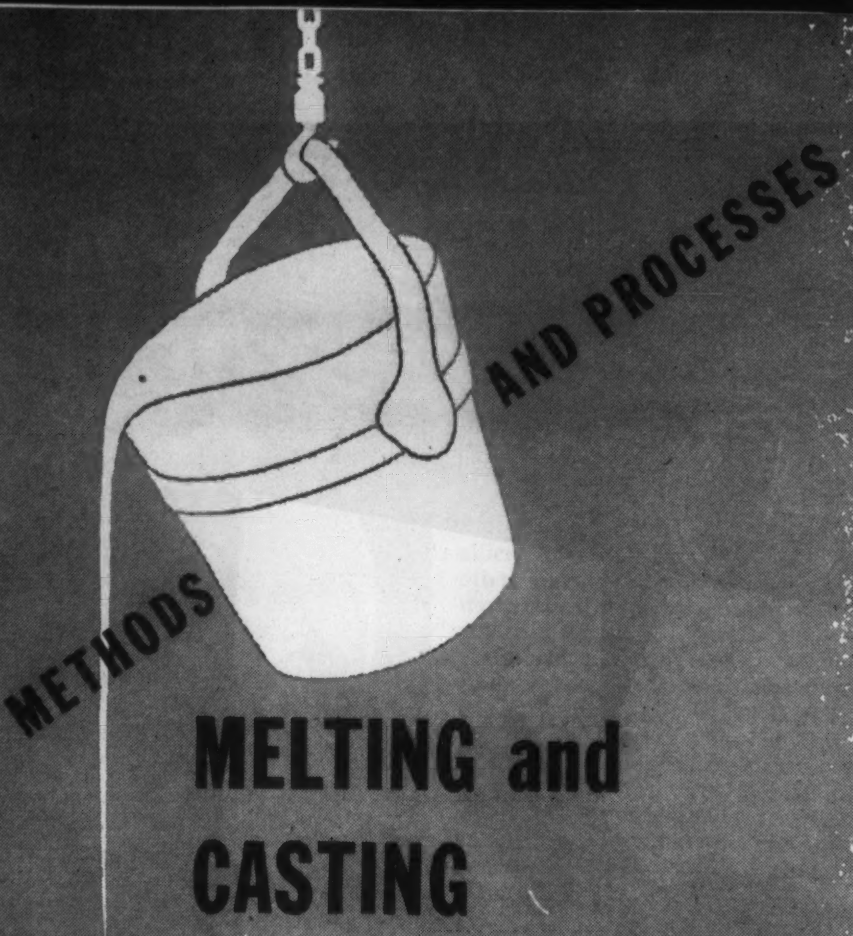
Keep tuned to Presteel through Pressprints. This monthly publication gives interesting information on current stamping accomplishments. If you wish your name on the list, write to:



**WORCESTER PRESSED STEEL CO.**

905 BARBER AVENUE, WORCESTER 6, MASS.

ALLOY STEELS AND OTHER METALS COLD FASHIONED SINCE 1883



# MELTING and CASTING

Melting, alloying, refining and casting methods, furnaces and machines. Iron and steel making, nonferrous metal production, foundry practice and equipment. Die casting, permanent mold casting, precision casting, etc. Refractories, control equipment and accessories for melting furnaces.

## Melting Metals in a Vacuum

*Condensed from a Paper of the Electrochemical Society*

Interest in vacuum metallurgy, brought about by the vacuum process for production of magnesium, may be expected to result in better purification techniques using melting and distillation, and in sounder castings. Use of a vacuum makes it possible to evaporate metals at greatly reduced temperatures, using large metal surfaces.

Apparatus of large cross-section is necessary to insure instant evacuation of the metal vapor. A minimum pressure of 1.8 mm. of mercury is required for rapid flow of the metal vapor to the condenser to ensure practical operation on a commercial scale.

Temperatures to which certain metals must be heated to obtain the 1.8 mm. pressure for commercially practical metal vapor flow are: Mercury, 139 C.; caesium, 300 C.; rubidium, 310 C.; potassium, 360 C.; cadmium, 420 C.; sodium, 450 C.; zinc, 505 C.; magnesium, 620 C. (sublimes); strontium, 760 C. (sublimes); lithium, 760 C.; calcium, 850 C. (sublimes); barium, 880 C.; lead, 1020 C.; tin, 1250 C.; manganese, 1280 C.; silver, 1340 C.; chromium, 1350 C. (sublimes); aluminum, 1520 C.; beryllium, 1550 C.; copper, 1630 C.; silicon, 1670 C.; iron, 1860 C.; nickel, 1930 C.; platinum, 2630 C.; molybdenum, 3010 C.; carbon, 3120 C.; and tungsten, 4000 C.

From this list it can be seen that lead is the last metal of the group that can be distilled in heat-resisting steel equipment, since its vaporization temperature at 1.8 mm. is 1020 C., while the extreme upper working temperature of these steels is 1200 C. Tin can be freed from lead as a contaminant in these types of furnaces.

Carbon resistor furnaces, not as yet used commercially, would extend the range to about 1600 C., above which the vacuum reaction of carbon with refractories becomes serious. High frequency heating can be used for higher temperatures.

Subliming may offer some advantages over distilling, but since diffusion rate of the metal to the surface of the charge governs evaporation velocity, and diffusion is a slow process, only slightly contaminated metals are suitable for sublimation. Magnesium is purified by this process.

Accurate specification of pressure and temperature to be used is necessary in vacuum metallurgy. Large metal losses during evaporation would cause failure if the best possible vacuum were used for melting. The less volatile metals are melted at pressures of 1 mm. to 10 mm.

Some metals, such as chromium and magnesium, cannot be melted in a good vacuum in an open crucible. Similarly, brass cannot be annealed in high vacuum without losing zinc, nor sheet iron at high temperature without losing manganese. Alpax aluminum-silicon alloy loses sodium. Most metals will sublime in an electronic vacuum, such as exists in a radio tube.

Alloys may be separated into component metals more easily in a vacuum than at atmospheric pressure. In a high frequency field, evaporation is higher.

—W. J. Kroll. Paper, *Electrochemical Soc.*, April 1945 meeting. 68 pages.

## Planning Magnesium Casting

*Condensed from "Light Metal Age"*

The general impression in this country is that magnesium is difficult to cast. Actually, if proper safety precautions are observed and good foundry techniques are developed, fire hazards can be eliminated, and castings produced with few rejects and good pour ratios.

The first step in planning for production of a casting job is to determine whether or not the foundry has the facilities for handling the job. Another point to consider is

WHEELABRATOR

gives you any finish you need

*faster—at lower cost*

Airless Wheelabrating produces finishes that are distinctive for their bright, clean, silvery appearance.

Any type of finish from fine to coarse, can be produced with the Wheelabrator by the proper selection of the size and type of abrasive.

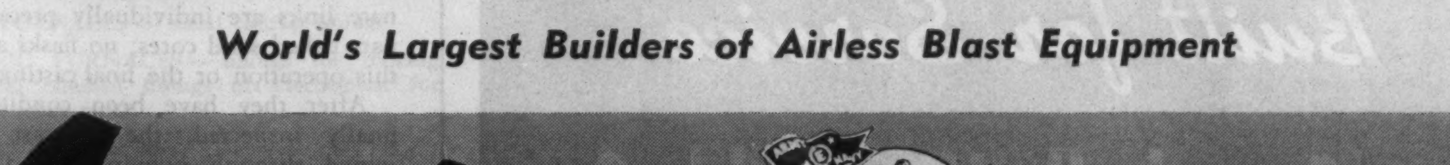
Light metal parts can be given a satin finish; and castings, forgings, heat treated parts and similar products can be blasted free of sand and heavy scale.

The Wheelabrator will also produce the superior finishes required for enameling, plating, galvanizing, painting and similar processes.

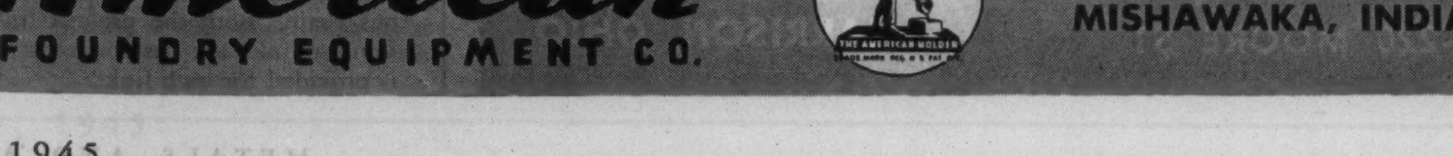
Examples of a few typical finishes produced by the Wheelabrator are illustrated below.

Send your products to our experimental department and let us show you how to achieve the type of finish you want. Write for more information today.

SHOT BLASTED FINISHES



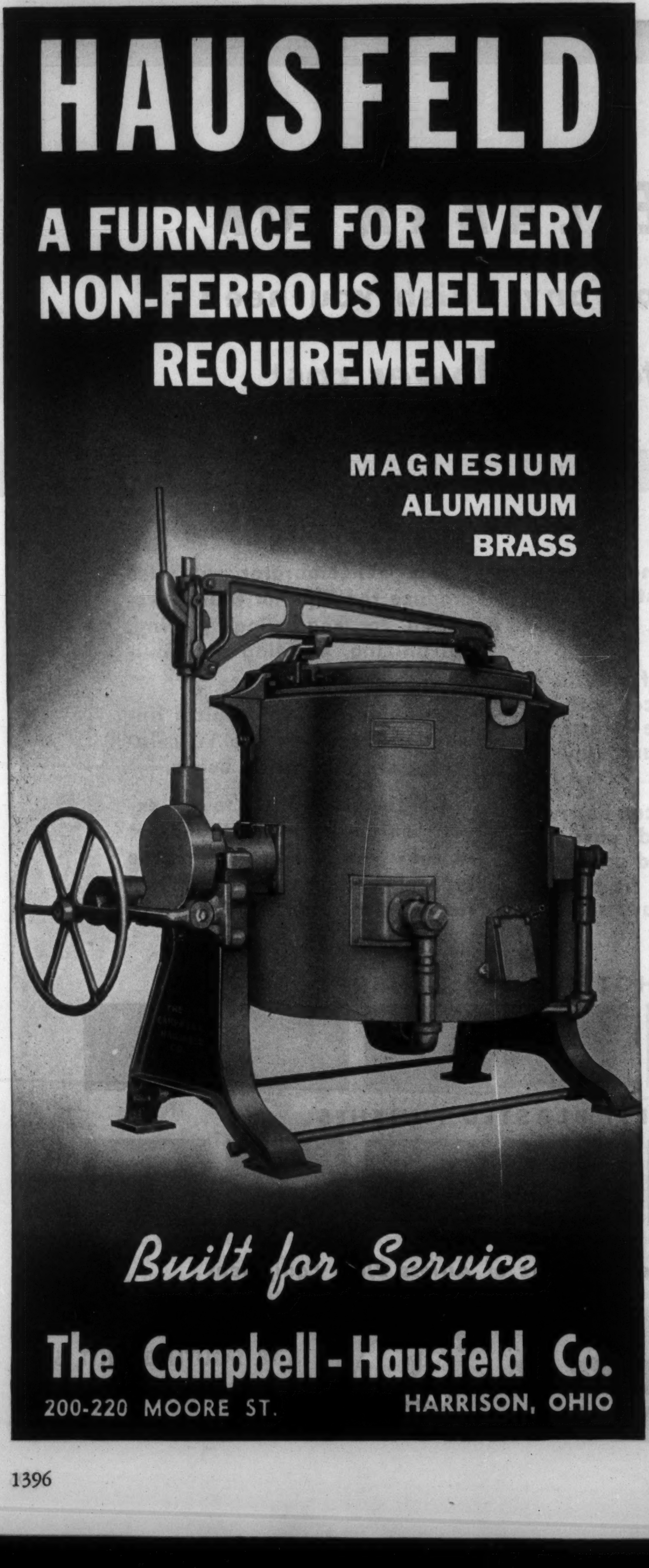
GRIT BLASTED FINISHES



*World's Largest Builders of Airless Blast Equipment*

*American*
FOUNDRY EQUIPMENT CO.

538 SOUTH BYRKIT ST.
MISHAWAKA, INDIANA



HAUSFELD

A FURNACE FOR EVERY NON-FERROUS MELTING REQUIREMENT

MAGNESIUM
ALUMINUM
BRASS

*Built for Service*

**The Campbell-Hausfeld Co.**

200-220 MOORE ST. HARRISON, OHIO

the possibility of including the new job in the regular schedule without affecting other commitments.

When it has been determined that production can be undertaken, all departments responsible for the manufacture of the casting should make a careful study of the blueprints. The design may be changed to facilitate molding and coremaking with consequent increased efficiency. Heat treating facilities should be checked because of the tendency of magnesium to warp during heat treatment. Special supporting jigs may be necessary.

All operational difficulties should be ironed out during the trial run. Wood patterns are not desirable because of the close dimensional tolerances required. Gates and risers should be designed carefully with an eye to the pouring temperatures. Temporary permanent gates should be attached to the pattern to eliminate variations that may affect the product. Pour ratio and cleaning should also be considered.

The first samples produced should be checked carefully by layout for dimensional tolerances before seeking approval of the customer. The sample should be X-rayed and thoroughly examined for internal defects through microscope and fracture tests. Once the casting is found sound, permanent photographic records should be made to show gates, risers and chills, so that reference may be made to these during production runs.

When the casting is placed in production, test runs should be made lasting at least one or two shifts. All castings during that period should be checked either by X-ray or fracture and micro-examination. The castings should be checked for dimensional accuracy to guard against any deviations from the trial run.

—Oscar Blohm & M. D. King. *Light Metal Age*, Vol. 2, Sept. 1944, pp. 20-23.

## Casting Steel Chain

*Condensed from "The Foundry"*

The author describes the physical requirements, manufacturing methods, and proof tests employed for cast-steel anchor chain as it is made in the Sharon, Pa., plant of the National Malleable & Steel Castings Co.

Nominal composition of the steel is 0.35 C, 1.40 Mn, 0.45 Si and 0.05% maximum for sulphur and phosphorus. The steel is melted in acid electric and acid open-hearth furnaces. Physical property specifications for the steel are: Yield point, 60,000 p.s.i.; tensile strength, 100,000 p.s.i.; elongation, 10%; reduction of area, 18%. These specifications are exceeded by comfortable margins in plant practice.

The anchor chain is made in lengths of 90 ft., traditionally called "shots." Alternate links are individually precast in two-part baked sand cores; no flasks are used in this operation or the final casting operation.

After they have been conditioned and finally inspected, the pre-cast links are joined through openings of a series of four-part baked sand cores so that the intervening links can be cast to form a continuous chain. Both the pre-cast links and the joining links are cast on edge and a riser is provided for each link.

## A FEW FACTS ABOUT CORHART PRODUCTS

**Corhart Electrocast Refractories are high-duty products manufactured by melting selected and controlled refractory batches in electric furnaces, and casting the molten material into molds. After careful annealing, the finished shapes are ready for shipment. Dense, high-melting refractories, they are especially designed for resistance to corrosive action.**

### PRODUCTS

CORHART STANDARD ELECTROCAST is a high-aluminous refractory.

CORHART ZED ELECTROCAST is Zirconia-bearing.

CORHART ELECTROPLAST is a high-temperature plastic refractory made from Standard Electrocast which has been ground and crushed. Especially designed for ramming. Furnished dry.

CORHART MORTAR is a high-quality cement for laying up Electrocast, clay brick, or any aluminous refractory.

### CHARACTERISTICS OF STANDARD ELECTROCAST

POROSITY: Less than 0.5%—therefore virtually no absorption.

FUSION POINT: Cone 38 without any appreciable softening below that point.

HARDNESS: 8, Mineralogist's scale.

SPECIFIC GRAVITY: Blocks weigh approximately 183 lbs. per cu. ft.

COEFFICIENT OF EXPANSION: 0.000006 between room temperature and 900° C.

SPECIFIC HEAT: 0.25 cal. per gm. per °C. at 980° C.

THERMAL CONDUCTIVITY: 25 BTU per sq. ft. per hour for gradient of 1°F. per inch.

COMPOSITION: Standard Electrocast is of an aluminous crystalline nature.

CORROSION: Because of low porosity and inherent chemical make-up, Corhart products are highly resistant to corrosive action.

### APPLICATIONS

Most heat processes present spots where a better refractory material is needed in order to provide a balanced unit and reduce the expense of repeated repairs. It is for such places of severe service that we invite inquiries regarding Corhart Products as the fortifying agents to provide the refractory "balance" desired.

The following is a partial list of applications for which Corhart Products are suggested:

ELECTROLYTIC CELLS — for production of Magnesium and other light metals.

SILICATE OF SODA FURNACES — sidewalls, bottoms, and breastwalls.

HEARTHS AND SMELTERS — for non-ferrous metals.

ALKALI AND BORAX MELTING FURNACES — fast-eroding portions.

GLASS FURNACES — the entire installation of flux walls and bottoms, breastwalls, ports, tuckstones, forehearths, recuperators, etc.

RECUPERATORS—tile, headers, separators, etc.

ENAMEL FRIT FURNACES — flux walls and bottom.

BRASS FURNACES — metal contact lining.

ELECTRIC FURNACES — linings for rocking type, and rammed linings of Electroplast for this and other types.

BOILERS — clinker line.

### STOCK SHAPES AND SPECIALS

Standard and Zed Electrocast are made in stock shapes and in many special shapes. The weight of individual pieces may run to 3500 pounds.

## IF YOU NEED

# A BETTER REFRACTORY—

● Corhart Electrocast Refractories are high-duty products which have proved considerably more effective than conventional refractories in certain severe services. If your processes contain spots where a better refractory is needed to provide a balanced unit and to reduce frequent repairs, Corhart Electrocast Refractories may possibly be the answer. The brief outline at the left gives some of the basic facts about our products. Further information will be gladly sent you on request.

Corhart Refractories Company, *Incorporated,* Sixteenth and Lee Streets, Louisville 10, Kentucky.

**"Corhart" is a trade-mark, registered U. S. Patent Office.**

QUALITY ECONOMY
ENDURANCE

# CORHART ELECTROCAST REFRACTORIES

WORKING WITH ALUMINUM?

Investigate this unique
HOLDING FURNACE
for
Improved Operations
and
Lowered Costs!

*Typical layout for die casting, showing compact 20 KW Ajax-Tama-Wyatt furnace in position. Unit comes with complete control cubicle, as shown.*

INDUCTION FURNACES MEAN A MODERN PLANT . . .

**In addition to the holding furnace here described, small, compact, twin-coil melting furnaces are likewise available for continuous production. Rolling mills and foundries using Ajax-Tama-Wyatt units have *consistently* developed the highest physical properties in their aluminum products . . . with decreased gas absorption, absence of all segregation, and elimination of oxide inclusions and hard spots . . .**

**Clean-cut temperature control, great ease and simplicity of handling are operating characteristics. Ajax induction furnaces give you a modern plant, a cooler foundry, a better product. Significantly, too, they have been known to pay for themselves within less than six months. *Write for latest TW catalogs describing both Ajax holding and melting furnaces for aluminum!***

ADVANTAGES

- Every element of uncertainty is removed from holding furnace procedure.
- Automatic, positive temperature control to within 5 degrees.
- No segregation, iron pickup, or contamination—automatic stirring.
- Always ready to operate—no heating up or waiting periods.
- Pays for itself quickly by doing away with pot or crucible replacements.
- Maintenance costs so low as to be virtually negligible.
- Low operating costs—only 12 KW for holding continuously up to 400 lb.; 8 KW when covered on week ends.
- Greatly improved overall foundry conditions inherent in induction melting.

AJAX ENGINEERING CORPORATION • BOX 1418 • TRENTON 7 • N. J.
AJAX TAMA-WYATT
INDUCTION MELTING FURNACE

AJAX METAL COMPANY, Non-Ferrous Ingot Metals and Alloys for Foundry Use
AJAX ELECTROTHERMIC CORP., Ajax-Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax-Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax-Wyatt Induction Furnaces for Melting
ASSOCIATE COMPANIES

In the final casting operation, the cores, with pre-cast links inserted, are arranged in two parallel rows so that a common sprue serves adjacent links, one in each chain. In this manner, shake-out and cleaning are facilitated. The risers are knocked off manually with sledge hammers.

After the chain has been conditioned and inspected, it is heat treated by water-quenching from 1700 F. and tempering at 1100 F. All chain is proof tested at a load 40% greater than that required for the corresponding size and type of wrought iron chain.

Examples of the proof load specified for cast steel anchor chain are 60,000 lb. for 1-in. diam. size and 1,037,800 lb. for 4½-in. diam. size.

—Pat Dwyer. *Foundry*, Vol. 73, Feb. 1945, pp. 74-77, 220, 222.

## Power for Fast Melting

*Condensed from "Blast Furnace and Steel Plant"*

In an electric arc furnace circuit, with voltage constant, the kva. increases directly with the increase in current. The kw. input, however, increases only until a current is reached that will produce a power-factor of 0.707 in the circuit. Further increases in current beyond this point result in a decrease in kw. input with increased kva. and lower power factor. Because of energy losses, the actual kw. input to the furnace itself reaches a maximum at some circuit power factor higher than 0.707.

By assuming various current values, calculating corresponding wattage values, and deducting power losses resulting from the resistance of all elements of the circuit between the metering point and the electrode, a curve of the actual power liberated at the arc and also the circuit efficiency can be plotted.

A separate curve must be plotted for each voltage. From the curves thus established, voltage and current settings may be selected to supply any heat input, within the limits of the capacity of the circuit, at the maximum power-factor and efficiency.

Perhaps the only positive way to accomplish the proper limitation in current setting to avoid exceeding the point of maximum power input is by actually calibrating the current regulating control. This is possible by replacing or installing resistors and arranging through voltage relays to insert a value of resistance for each transformer tap which would limit the current setting when operating at that tap to a value corresponding to maximum power input, or slightly below.

Speed of melting is affected also by the sensitivity and speed of response of the control system. The slower the time of response, the lower will be the actual power input. Rotating controls, because of their fast response, have given substantial reduction in time of melting.

The supply of maximum heat to the arc may not necessarily be the condition of maximum production. It seems certain that the ideal heat input varies with the nature of the scrap.

The heat receptivity of the charge decreases as its temperature rises, and any rate

# CONTROL

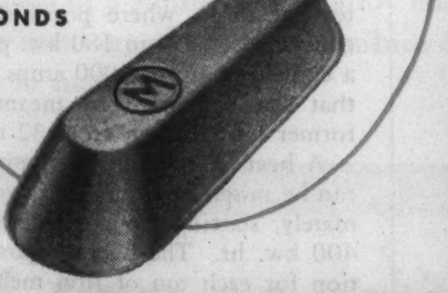
## IS THE THING........

Whether it's directing artillery fire, or turning out non-ferrous alloy ingot to definite and rigid specifications—control is the thing.

Rapid Analysis made while the alloy is still in the furnace enables us to make necessary adjustments in its composition, so the ingot, when cast, will be axactly what your order calls for.

If your products use or can use non-ferrous alloy ingot, remember us as a completely dependable source with which to do business.

**BUY WAR BONDS**



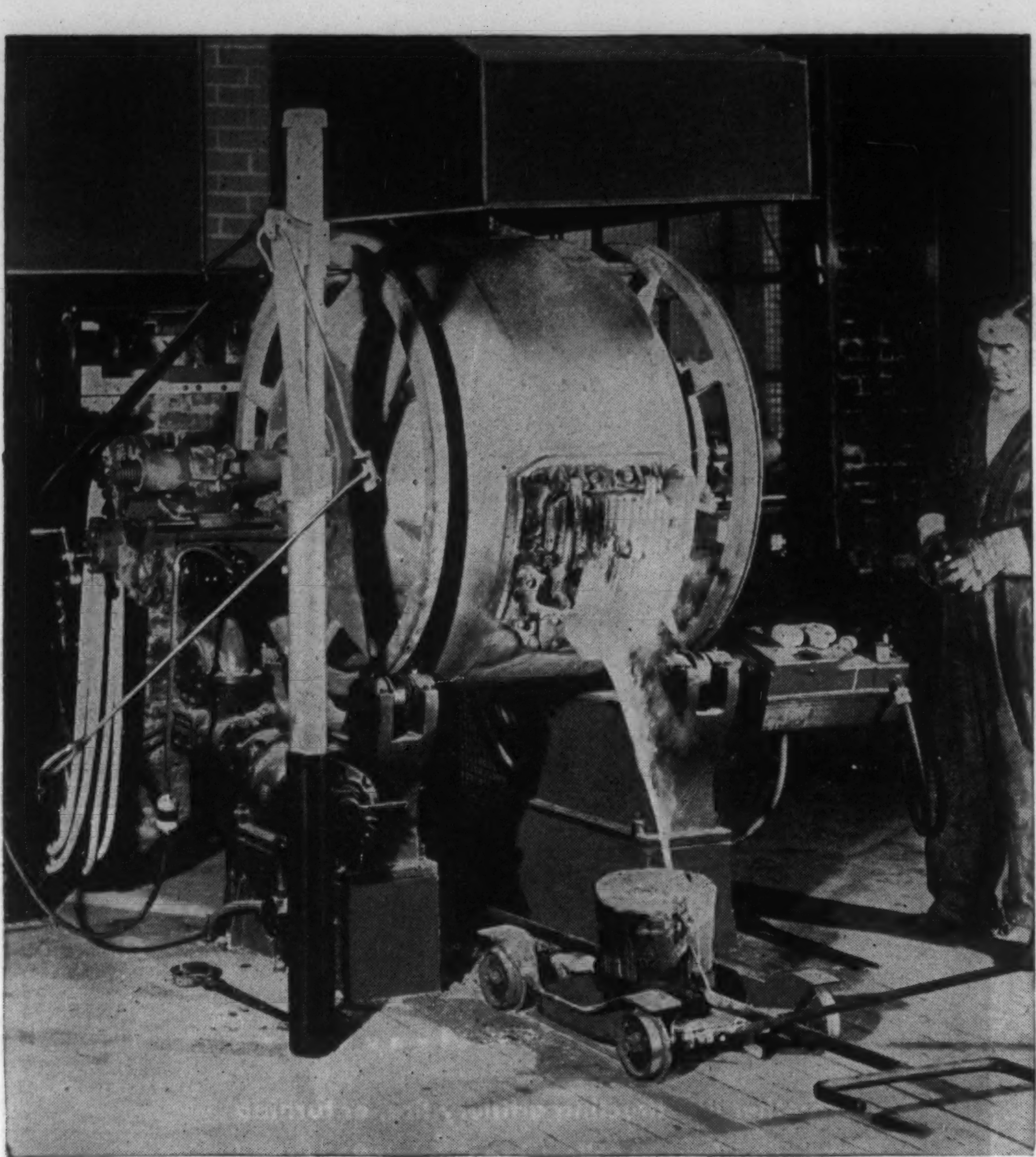
**MICHIGAN SMELTING & REFINING**

*Division of*

**BOHN ALUMINUM & BRASS CORPORATION**

*General Offices: Lafayette Buiding • Detroit 26, Mich.*

**NON-FERROUS SCRAP METAL REFINERS FOR OVER 50 YEARS**



LITTLE GLUTTON WITH A BIG APPETITE

You're sure of better casting results with a Detroit Rocking Electric Furnace in your foundry. Swift and efficient, these veritable gluttons can produce an amazing volume of metal quickly with little labor and of consistently high quality.

Outstanding engineering and design principles of Detroit Furnaces permit automatic stirring action under non-oxidizing conditions and precise control over time, temperature, and composition—vital melting elements. They eliminate combustion products: melting takes place in a closed chamber, thus reducing dirt and fumes to a minimum. They assure volume production—as many as 8 ferrous or 16 non-ferrous heats in one 8-hour day. They insure lower metal losses, less machine shop scrap, and a higher percentage yield of perfect castings of uniform quality.

Versatile, flexible and fast, the Detroit Rocking Electric Furnace has proved its worth in scores of foundries throughout the country. Available in sizes from 10 lbs. to 4 tons. Write for complete facts.

DETROIT ELECTRIC FURNACE DIVISION
KUHLMAN ELECTRIC COMPANY • BAY CITY, MICHIGAN

of power input beyond the receptivity of the charge will result in excessive transfer of heat to the walls and roof, resulting in decreased life of refractories and excessive radiation losses.

The real usefulness of the characteristic curves of a furnace begins when it has been determined how much heat is wanted at various parts of the melting and refining cycle. In addition to attaining maximum production, using proper values of current and voltage will save about $1 per ton, because of less kwh., lower electrode consumption, improvement of power-factor, and reduction in demand.

—N. J. Roberts. *Blast Furnace & Steel Plant*, Vol. 33, Feb. 1945, pp. 237-240.

## Electric Rocking Resistor Furnace

*Condensed from "Foundry Trade Journal"*

The electric rocking resistor type of furnace has many desirable features in connection with the refining and superheating of high-duty and alloy cast iron. It is also used successfully in some non-ferrous foundries and for melting steel for small castings. There is no local intense heat, as with an arc furnace, the resistor heating the metal and furnace wall by uniform radiation from its whole length.

The furnace consists of a refractory-lined cylindrical steel shell, mounted on four rollers, with its long axis horizontal. A doorway is situated centrally for charging and slagging. The two ends are formed by cylindrical refractory slabs, which in the case of a rammed lining are rammed separately in a corebox.

In the center of each end is an aperture in which a copper or steel water jacket is inserted, and through which the carbon element or resistor passes. This resistor is held in a thick carbon block at either end, the block being in turn screwed on to a water-cooled holder.

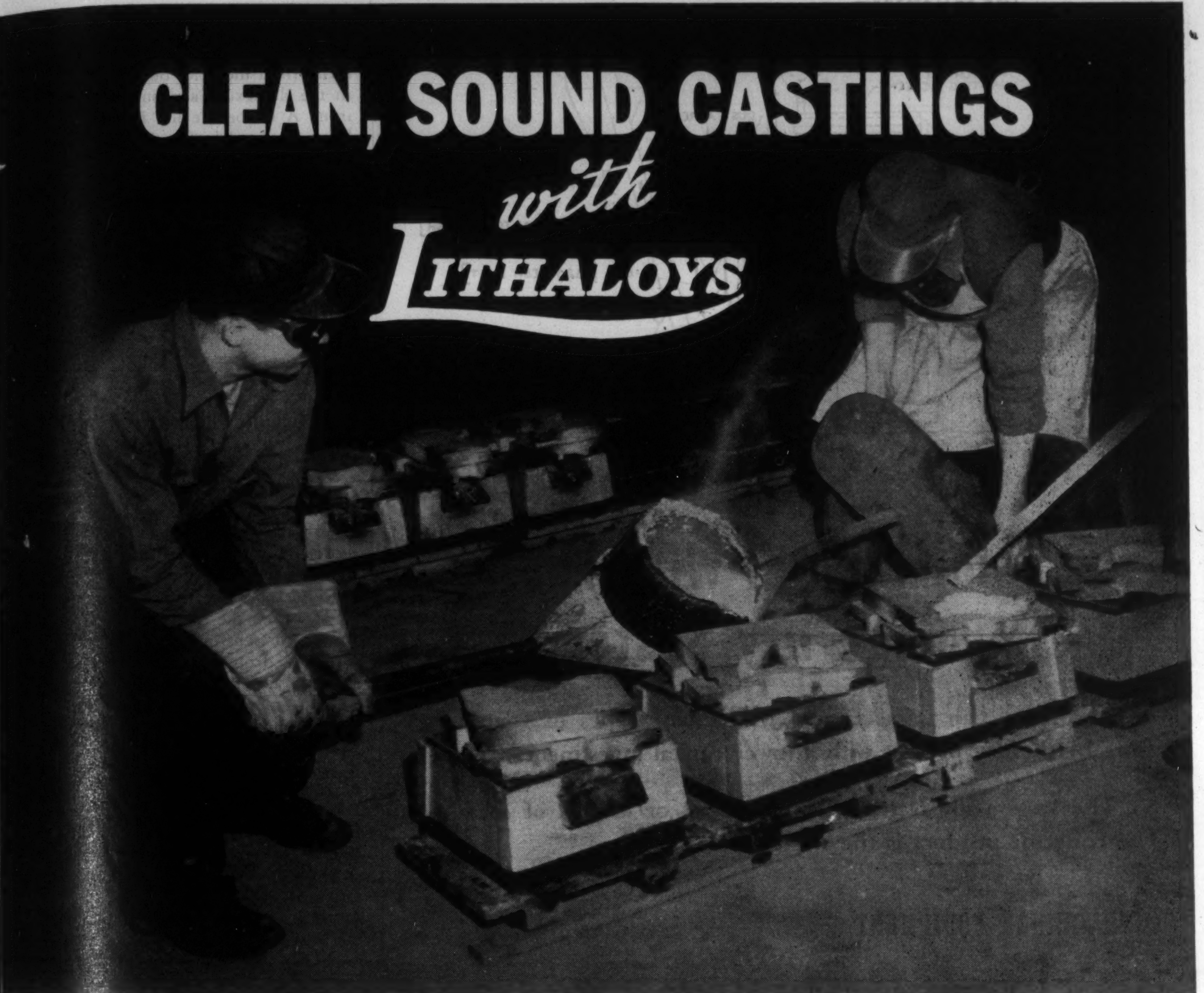
One of these blocks has a deeper hole in it than the other, and holds the resistor firmly. The other block has only a shallow hole in it, and the contact between it and the resistor is maintained by pressure alone, afforded by means of springs at either end of the furnace.

The furnace works on single-phase current, and, therefore, in order to have a balanced load, it is advisable to have a battery of three, where possible. The power consumed is 150 to 180 kw. per hr., taking a current of up to 5000 amps. at a pressure that can be varied by means of a transformer tap changer, from 32 to 61 volts.

A heat of 1000 lb. of pig-iron and scrap can be raised to 1450 C. in two hr. approximately, starting from the cold, using some 400 kw. hr. The average power consumption for each ton of iron melted is 900 to 950 kw. hr.

The furnace is tilted for pouring. It is capable of being automatically rocked backwards and forwards through an arc of some 120°. The capacity of the furnace is usually from 600 to 1200 lb. of molten cast iron. The lining found most suitable

# CLEAN, SOUND CASTINGS *with* LITHALOYS



LITHIUM treated melts of copper, tin bronze and silicon bronze consistently yield castings more uniformly free from porosity and gas cavities. At the same time, Lithium treatment effectively removes non-metallic impurities. As a result, the castings have optimum physical characteristics.

Lithium treatment is simple. A few minutes before pouring, Lithium metal is stirred into the melt in the form of a stable master alloy containing a small percentage of Lithium combined with other metals to match the melt.

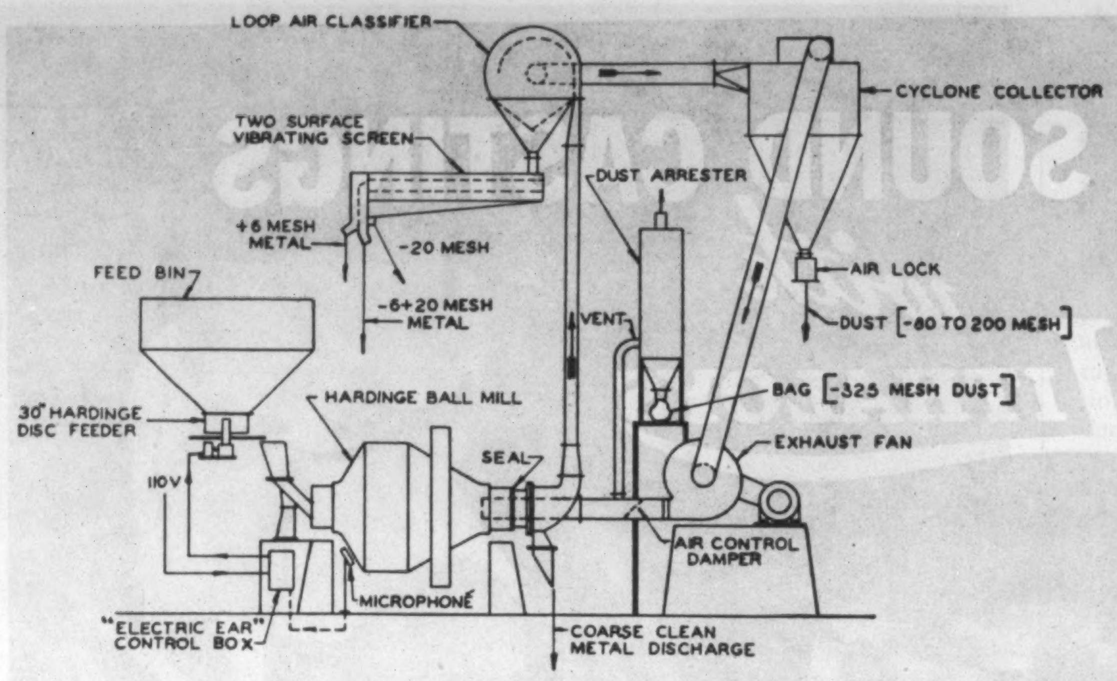
Lithium combines with hydrogen, nitrogen, oxides, sulphides and other non-metallic impurities. The compounds so formed are of non-metallic nature, and have low specific gravity. They are insoluble in the metal and flux out quickly.

This effective treatment costs only a small fraction of the price of *one* reject, and requires no special equipment, training nor departure from conventional foundry practice. Our technical staff, with over 15 years' experience in the Lithium and foundry fields will help you investigate.

**LITHALOYS CORPORATION**

**444 MADISON AVENUE, NEW YORK 22, N. Y.**

5-LC-1



# Reclaim Metal With The Hardinge Dry System

The metal can be reclaimed from many types of foundry waste by the dry process with a lower capital investment.

The system illustrated will produce 3 or 4 sizes of metal. The collector product is the waste.

## HARDINGE EQUIPMENT

| | Bulletin No. |
|---|---|
| Agitators | 31-C |
| Clarifiers | 31-C |
| Classifiers, Air | 17-B |
| Classifiers, Counter-Current | 39-A |
| Classifiers, Hydro | 31-C |
| Conveyors, Rotary | 44 |
| Density Stabilizer | 42 |
| Digesters | 35-B |
| Dryers | 16-C |
| "Electric Ear" | 42 |
| Feeders, Belt | 33-C |
| Feeders, Constant Weight | 33-C |
| Feeders, Disc | 33-C |
| Feeders, Drum | 33-C |
| Feeders, Non-Flooding | 33-C |
| Feeders, Weight Recording | 43 |
| Filters, Sand | 30-A |
| Metal Reclamation | 8-A |
| Mills, Batch | 19-A |
| Mills, Conical Ball | 13-D |
| Mills, Conical Pebble | 13-D |
| Mills, Rod | 25-B |
| Mills, Tube | 18-A |
| Mixers, Slurry | 31-C |
| Pumps, Diaphragm | 32 |
| "Ruggles-Coles" Dryers | 16-C |
| Kilns and Coolers | 16-C |
| Scrubbers, Conical | 37 |
| "Thermomill" | 17-B |
| Thickeners | 31-C |

*Advantages*

(1) An air cleaned metal free from fines.

(2) Waste collected without the use of conveyors or elevators.

(3) Fine waste removed before screening.

We also manufacture wet reclaiming systems.

*Write for Bulletin No. 8-A.*

HARDINGE
COMPANY, INCORPORATED — YORK, PENNSYLVANIA
NEW YORK, CHICAGO, SAN FRANCISCO, TORONTO

CONICAL MILLS
COUNTER CURRENT CLASSIFIERS
THICKENERS CLARIFIERS
RUGGLES-COLES DRYERS
CONSTANT WEIGHT FEEDERS
TUBE ROD AND BATCH MILLS

for melting cast iron is of rammed ground ganister.

The furnace may be used for melting metal from the cold, but its special field is in the duplexing and superheating of cast iron. A reasonable life for a lining, when being used solely for duplexing cast iron, is about 1000 heats, which is equivalent to approximately 450 tons. The maximum safe temperature to which the furnace can be raised, with a lining of rammed ganister, is about 1550 C.

—C. S. Johnson. *Foundry Trade J.*, Vol. 75, Jan. 11, 1945, pp. 31-33.

## Mullite Open Hearth Roof

*Condensed from "Steel"*

The initial installation of a mullite roof in an open-hearth furnace did not give the results anticipated. The life of the center section of the roof was shortened because the construction employed established a pinching effect, which was impossible to arrest during the campaign.

From present indications, the spalling in the roof from knuckle to endwall has stopped, and there has been little erosion since the new center section was installed. If this condition continues, this mullite end section of the roof may stand up during the life of several center sections. Pinching in future installations will be eliminated. Future plans call for a fully suspended center section from knuckle to knuckle, which should also eliminate any pinching.

The steel industry has found no satisfactory answer relative to the roof life desired. A satisfactory refractory for this application will mean increased operating temperatures, lower fuel consumption, and less shutdowns for repairs.

Mullite, because of its ideal softening point for the operating temperature of an open-hearth furnace, bears promise of obtaining the desired results. At 3000 F. with a load of 50 p.s.i., mullite shows less than 2% deformation. It is the only stable refractory at 3000 F. No spalling occurs in a mullite brick, nor are oxide penetrations experienced.

Precautions should be taken when setting up mullite brick to see that no magnesite brick or cement is in contact with the material, as magnesite and mullite flux each other. Silica drip also is detrimental to mullite.

Mullite is being used successfully in many applications in the steel industry. Average life of electric-furnace roofs has been increased three times. Continuous pipe furnace campaigns have been extended from six to 26 weeks, with increased production of over 50%. Average life of normalizing and forging furnaces has been increased three to four times.

Slag and tap-hole block for cupolas now stay in service for one complete heat, never before done. Burner blocks for numerous applications give lower fuel consumption and better control of furnace because of uniformity of orifice, with greater production in continuous furnace operations.

—C. W. Fyfe. *Steel*, Vol. 116, Feb. 19, 1945, pp. 128, 164.

For making better tap holes, and for quick hot repairs at critical points inside the furnace, more and more operators are using 695 Plastic. Where conditions are severe and operating temperatures unusually high, this basic plastic refractory gives excellent service.

IT'S A GOOD PHONE NUMBER TO KNOW

THERE are times when a steel man has his refractory troubles—he may be making tap holes too often, having excess bottom delay time, having too many break-outs, or an old bottom may need a major repair or renewal.

Then is the time to think of the "Basic" Engineer. Just give him a call, and he will be right over. For he's your "First Helper" in any emergency on refractories—he is trained to work that way.

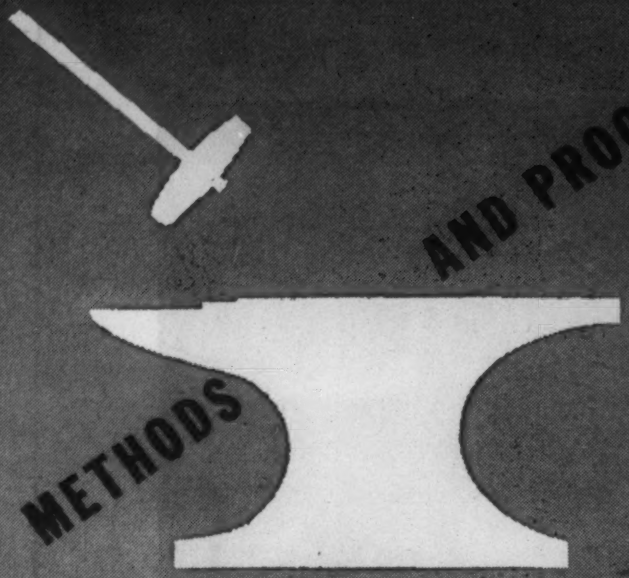
The "Basic" Sales Engineer is different from many of the sales representatives who ask you for business—different in that he is charged specifically with a double responsibility. His first duty is to help his customers to more effective use of refractories, and thus to contribute to increased steel production and lower refractory costs. He works on the theory that if "Basic" products acquit themselves satisfactorily, the orders will be forthcoming, too.

You can always depend on the advice of the "Basic" Engineer, for he is a practical steel man, too. In addition to his sound knowledge of basic refractories, he knows steel production as a man with actual experience in making open hearth and electric furnace steel.

So write his phone number at the top of your list. Comes any emergency, it's a good number to know.

BASIC FURNACE
REFRACTORIES

**BASIC REFRACTORIES, INCORPORATED**
845 HANNA BUILDING
*Cleveland 15, Ohio*



## METHODS AND PROCESSES

# FABRICATION and TREATMENT

**Machining, forging, forming, heat treating and heating, welding and joining, cleaning and finishing of solid materials. Methods, equipment, auxiliaries and control instruments for processing metals and nonmetals and for product fabrication.**

### Reclaiming Zinc Chromate Primer

*Condensed from "Industrial Finishing"*

The importance of reclaiming zinc chromate primer overspray will be seen in the statement that approximately only 50% of the paint leaving the spray gun reaches the part. The balance collects as a sludge in a tank below the water wash spray booth or deposits on the conveyor. The Lockheed Co., at the request of the Army, undertook the problem of reclaiming primer from the water wash sludge.

The process developed consisted of washing the sludge with several changes of water to eliminate the deflocculating agent and particles of wood, paper, or metal. Most of the water was then mechanically pressed from the sludge. The resulting cake was sliced into thin flakes and dried in a vacuum for 24 hr., using calcium chloride as a desiccant. The calculated amount of solvent was then added and the mixture stirred for several hr. A smooth, creamy mass resembling the original material results.

The above method of drying is necessary in order to avoid heating, which would polymerize the resins in the sludge.

The process as carried out on a commercial scale omitted the vacuum drying, leading to a product containing about 10% water. Panels sprayed with this material have been tested in a weatherometer, a salt spray box, and an outdoor weathering rack for a period of two months, and in all tests they were superior in durability to panels sprayed with new primer.

The reclaimed material was satisfactory on almost all specification items. The only points on which a significant difference were noted are (1) the film produced is not quite as smooth as standard; (2) it is somewhat more difficult to produce a homogeneous mixture on thinning.

It is recommended that the reclaimed primer be used on all airplane assembly work except exterior surfaces. It is felt that if a company engaged in the manufacture of automobiles or other items requiring a primer were to obtain used sludge from an aircraft plant where it is used in large quantities, and from whom it could be obtained for a low price, and then do its own processing, the reclaimed primer could be used at a considerable saving and would be satisfactory in every respect.

—Maxwell Stiles. *Ind. Finishing*, Vol. 21, Feb. 1945, pp. 32, 34, 36, 38, 40.

### Production of Metal Powders

*Condensed from a Paper of the Electrochemical Society*

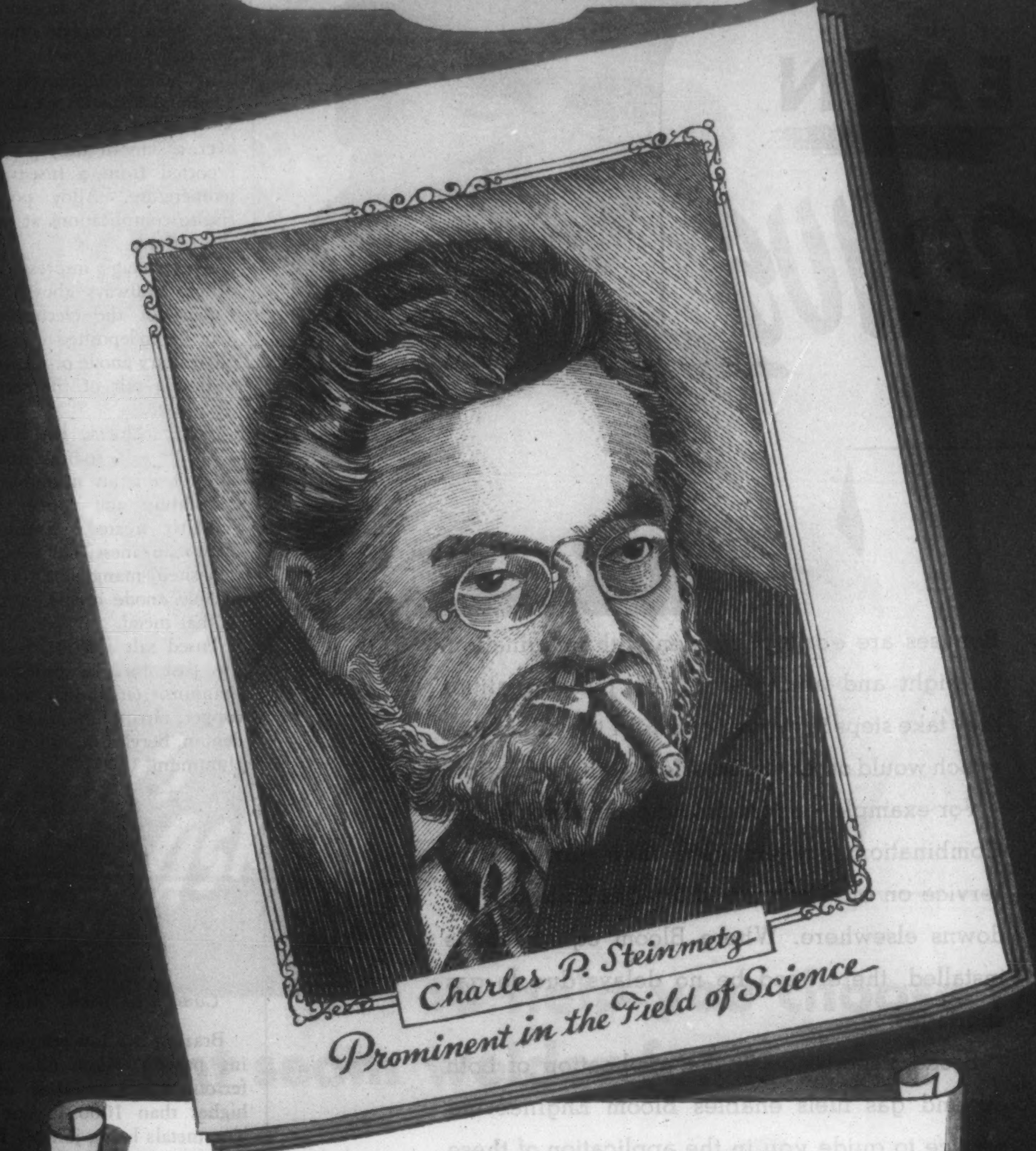
Studies of the production of relatively pure metal powders or metal-alloy powders were suggested by the recent widespread interest in powder metallurgy. The three major metal products of the fused electrolyte industry are sodium, aluminum and magnesium, each of which is removed from the cells in liquid form. However, when the cathode deposit is solid, the dendritic mass is interspersed with electrolyte, and the recovery of the metal and its separation from the bath is difficult.

When the melting point of the metal is above the bath temperature, the metal will be deposited as small crystals or as dendrites. About 20 metals have been so deposited. Current densities up to about 4 amp. per sq. dm. will yield a smooth plate of metal, varying somewhat with the nature of the metal, and with that of the bath.

Above about 4 amp. dendrites appear, causing a progressive drop in the cathode potential due to increase in actual cathode surface. Eventually, there may be serious treeing at the cathode and resultant short-circuiting.

QUALITY ASSURES

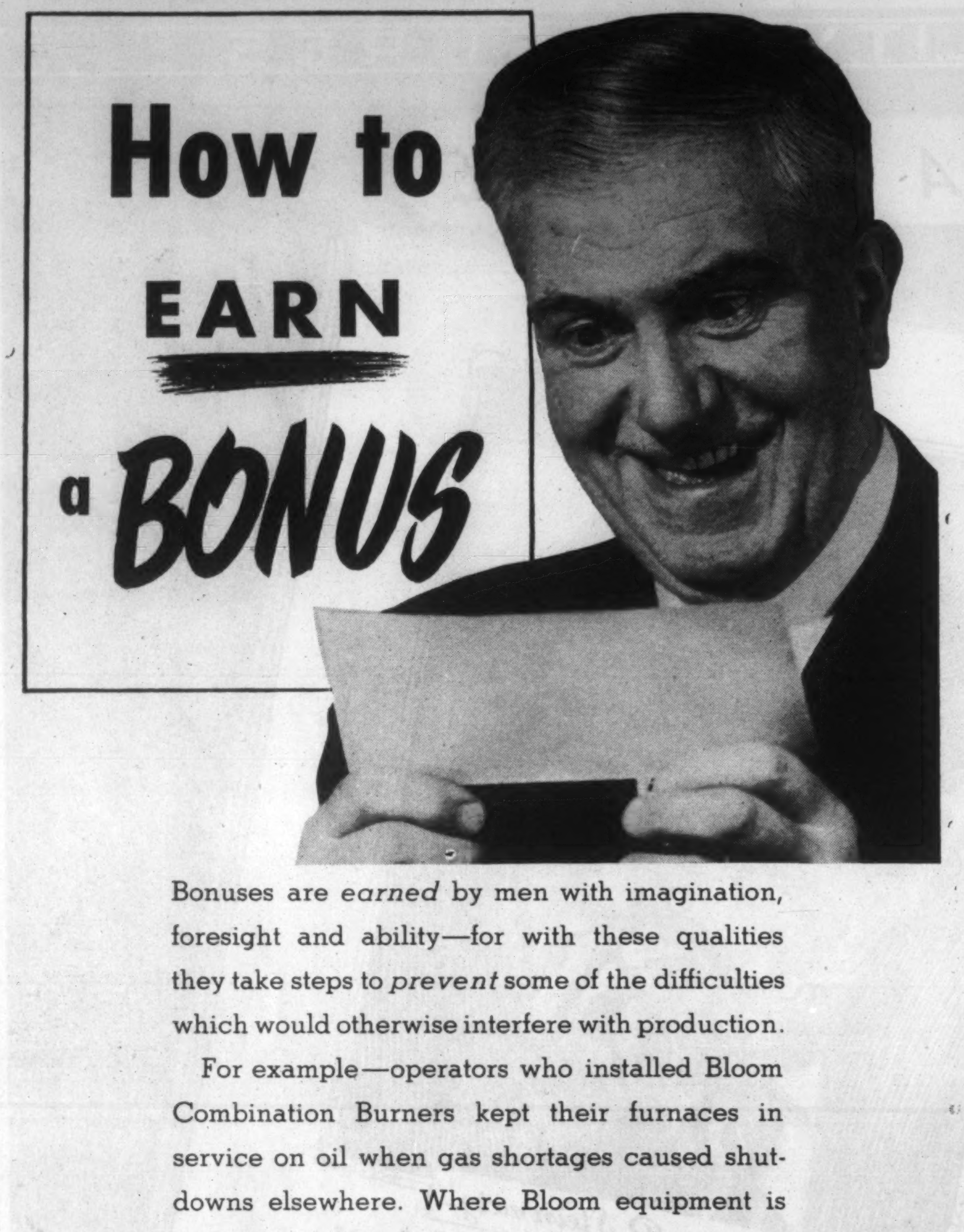
# A GOOD NAME


Charles P. Steinmetz
Prominent in the Field of Science

**Profuse and convincing references to a poverty stricken emigrant, hopelessly deformed and terribly handicapped, would draw compassion from the hearts of normal men. Without almost insurmountable odds that exacted tireless effort, the genius of Steinmetz might never have made such resplendent contributions to the electrical industry.**

**Steinmetz dedicated his life to the advancement of science; his good name is a symbol to posterity.**

**ELECTRO-ALLOYS *Division***
ELYRIA, OHIO.
MAKERS OF
*X-RAY Inspected* *Thermalloy*
AMERICAN **Brake Shoe** COMPANY
HEAT AND CORROSION RESISTANT CASTINGS



Bonuses are *earned* by men with imagination, foresight and ability—for with these qualities they take steps to *prevent* some of the difficulties which would otherwise interfere with production.

For example—operators who installed Bloom Combination Burners kept their furnaces in service on oil when gas shortages caused shutdowns elsewhere. Where Bloom equipment is installed, there need be no delays due to gas shortages.

Broad experience in the application of both oil and gas fuels enables Bloom Engineering service to guide *you* in the application of these burners for greatest efficiency and effectiveness.

Write for Bulletin 1001, containing full details; principle of operation, capacities, dimensions, weights, etc.

**BLOOM**
**ENGINEERING CO.**
857 WEST NORTH AVENUE
PITTSBURGH 12, PA.

The cathode deposit, composed of fine crystals, may be compacted in situ, for instance, by rotating two cylindrical cathodes against each other, or the mass of crystals plus electrolyte may be consolidated after removal from the bath by centrifuging, or simply by compressing. The latter method permits enrichment of the metal content from about 20% to more than 55%. The entrapped electrolyte must be separated and eventually reclaimed.

At low current densities, where smooth single-metal plates are deposited from fused salts, alloys may also be deposited. However, a smooth alloy plate has not yet been reported from a fused electrolyte at low temperature. Alloy potentials may give rise to complications at both the anode and the cathode.

The voltage impressed to produce dendrites is always above the decomposition voltage of the electrolyzed salts. Metals may be codeposited either by using a supplementary anode of the second metal, or by adding a salt of the second metal to the electrolyte.

Ferric chloride has been electrolyzed in a carrier salt, sodium and potassium chlorides, using an insoluble anode, graphite. Chromium and copper chlorides can be similarly treated. A soluble alloy anode, ferro-manganese, has been used for electrodeposited manganese. Use of iron as a soluble anode occurs in the electrorefining of that metal.

Fused salt electrolysis has been used in the past for the production of thorium, uranium, tantalum, cobalt, nickel, iron, copper, zirconium, silver, platinum, molybdenum, beryllium, tungsten, chromium, and aluminum.

—W. J. Kroll. Paper, *Electrochemical Soc.*, April 1945 meeting. 54 pages.

## Brazing

*Condensed from "Mill and Factory"*

Brazing is a low-temperature metals joining process whose filler metal is a nonferrous metal or alloy of melting point higher than 1000 F. but lower than the base metals being joined. It is useful where the part is too intricate for forging, or too small or of unfavorable composition for welding, where liquid or pressure tightness is required, and for electrical connections.

Usually the bond has an efficiency between 90 and 98% of the base metal. Butt-brazed joints in copper conductors have 98 to 99% of the conductivity of the copper, while lap joints have 102 to 104% conductivity. Since brazing alloys are copper or copper-silver alloys, they are highly non-corrosive.

In a butt joint thickness should be 0.002 in., and never more than 0.005 in. The scarf joint is a modification of the butt joint, with an angle of 45° usually selected. Strength is comparable to the butt joint, but is more ductile and with electrical conductivity greater. The lap joint is almost universally used because of simplicity and greater safety factor.

Phos-copper alloys are preferred for joining copper to copper because the phos-

special tooling
seam and roll spot welding machines
Yours for the Asking

# to help you choose the **right** seam welder for the job

THIS 24 page booklet fully describes 3 of Sciaky's new 180 KVA seam welders. Included is much general information, tooling data and application suggestions. ***Seam welding*** can produce pressure-tight lap joints or a series of closely spaced spot welds at ***great speed.*** The booklet is designed to help you fit this fast, modern fabricating method into your production problems.

Sciaky machines are built with the stamina of a machine tool . . . to stand up under day in and out operation. Control is entirely electronic and the welder is a complete, self contained unit.

Just fill in and mail the coupon for your copy of bulletin 113-A.

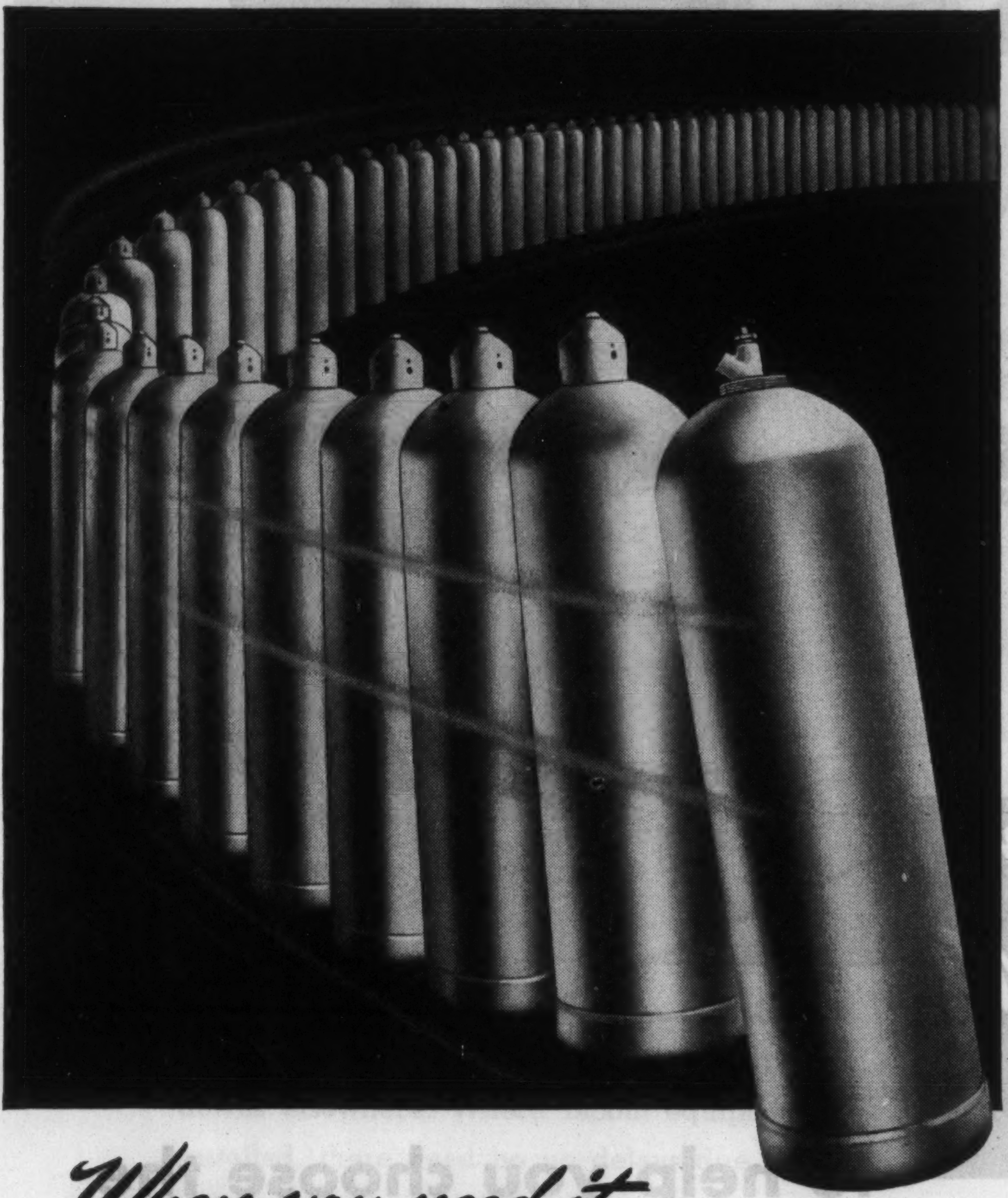
SCIAKY BROS.

**Sciaky Bros.** **3-5**
**4915 W. 67th St.**
**Chicago 38, Ill.**

**Yes, please send your bulletin No. 113-A, describing the new Sciaky 180 KVA Seam Welders.**

**Name** ____________ **Position** ____________
**Company** ____________
**Address** ____________
**City** ____________ **State** ____________

armour's PURE AMMONIA



*When you need it... Where you need it...FAST!*

Armour knows what it takes for your heat treating . . . knows that when you need ammonia you need it in a hurry! That's why your orders are shipped promptly. What's more, 65 conveniently-located stock points mean prompt delivery. Many customers receive their shipments of Armour's Anhydrous Ammonia *within 24 hours.*

Armour's Anhydrous Ammonia is pure and dry with a Dew Point of −60°F. It's widely used in Nitriding, Dry Cyaniding, Dissociation and other applications. Orders can be filled in either bottle or tube type cylinders.

There's no sacrifice in quality with this superior service. Armour *tests every cylinder for purity.*

So remember: prompt delivery, product dependability and technical advice are as near as your phone. Call Armour today.

**ARMOUR AMMONIA WORKS**

*"Headquarters for Ammonia Service"*

A Division of Armour and Company
120 BROADWAY, NEW YORK 5, NEW YORK
1355 WEST 31st STREET, CHICAGO 9, ILLINOIS
Or your nearest Armour branch

phorus acts as the fluxing agent; it will not braze steel parts. Its flow temperature is slightly higher than the silver solders generally used, and it is less expensive. Pure copper is excellent for steel parts where high joint strength is needed, and the high brazing temperatures may be obtained without affecting the physical properties of the assembly.

There are three methods of application: Hand feeding, pre-placing and pre-filled reservoirs. Rods or strips are adopted for hand feeding. Pre-placing the alloy is good for repetitive parts, preventing waste and controlling the brazing time. It is preplaced as inserts of thin sheets, flat washers or rings, or powder. Often a groove or reservoir is cut in tubular joints and pre-filled with brazing material.

Before brazing, the importance of good cleaning cannot be overemphasized. Chemical cleaning is more efficient than mechanical. The part is then dipped into an acid solution, rinsed and dried quickly. Fluxing protects the metals from oxidation while heating dissolves any oxides that form and assists the flow of the brazing alloy.

Patented fluxes are recommended since they have a flow-point between 800 and 1100 F., which is below the 1175 to 1300 F. melting point silver solders. Parts should be heated uniformly and as quickly as possible, with the heavier section or one of higher conductivity being favored. The flame should be directed on the under side of the joint and away from the brazing alloy.

—L. D. Jennings. *Mill & Factory*, Vol. 36, Feb. 1945, pp. 140-141, 262, 264, 268, 270, 272.

## Forging of Steel

*Condensed from "Canadian Metals and Metallurgical Industries"*

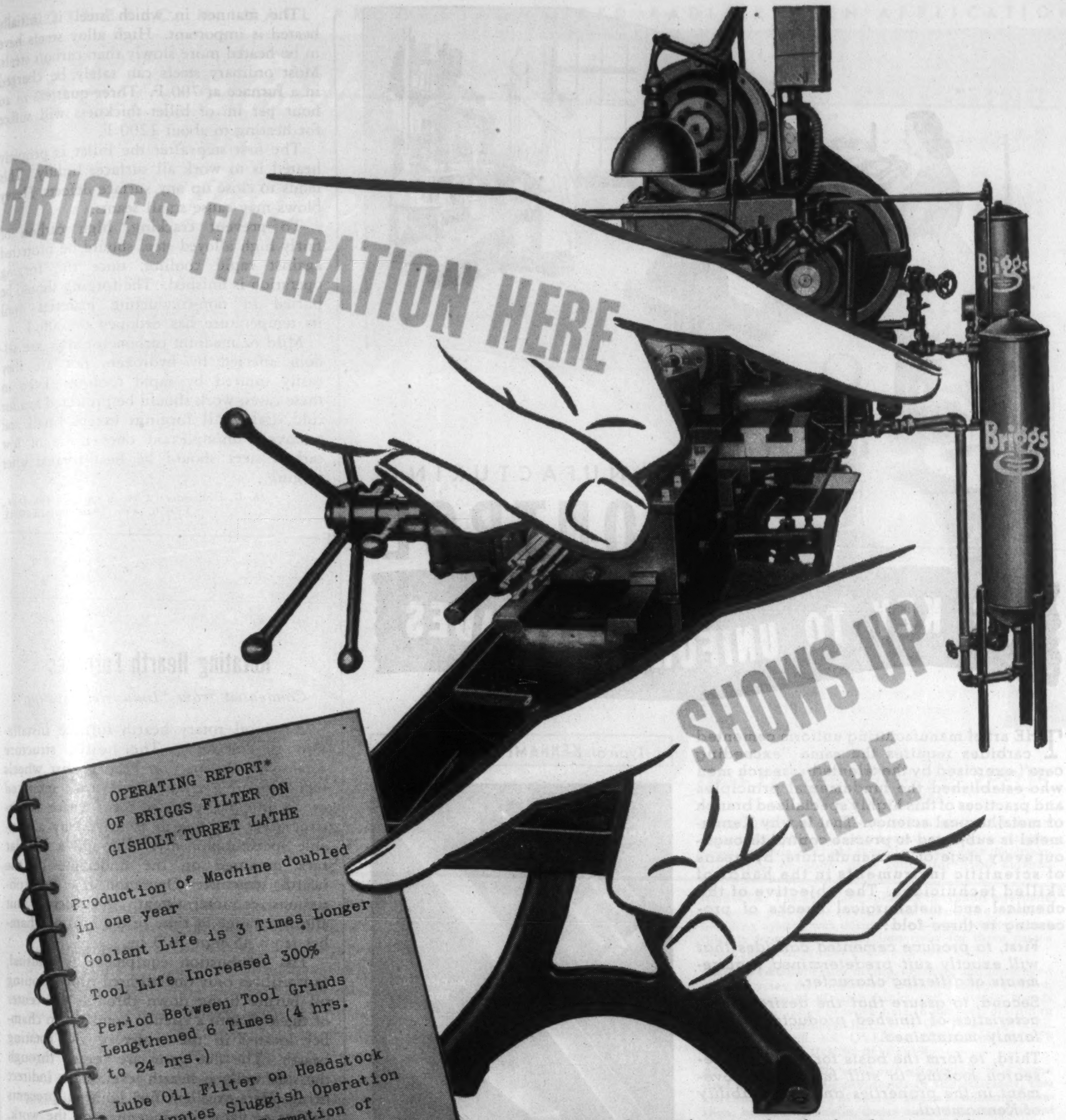
Steel for forging purposes is usually fully killed. That is, deoxidizing agents are added to eliminate impurities. One of the defects in billets is hydrogen embrittlement. This is usually caused by moisture in the charge; it may be chemically combined in the rust.

If steel is cooled slowly after forging, hydrogen seems to work to the surface and disappear. Shattered cracks are believed to occur between 950 and 300 F., and, therefore, slow cooling should be started above the higher of these temperatures and completed below the lower.

Improvement in forging is governed by the ratio of reduction. If too little forging is done, the dendritic crystals will not be broken up. These may be refined by double normalizing and similar treatments, but it is very difficult to do so by heat treatment alone, rather than by rolling or forging before heat treatment.

Certain forgings, such as gun barrels and pressure vessels, require their maximum strength to be developed in circumferential direction. Tests are, therefore, taken tangentially to the bore.

When transverse tests are required, steel must be sound. Low carbon straight nickel steels sometimes show a banded structure, which is very objectionable.



OPERATING REPORT*
OF BRIGGS FILTER ON
GISHOLT TURRET LATHE

- Production of Machine doubled in one year
- Coolant Life is 3 Times Longer
- Tool Life Increased 300%
- Period Between Tool Grinds Lengthened 6 Times (4 hrs. to 24 hrs.)
- Lube Oil Filter on Headstock Eliminates Sluggish Operation by Preventing Formation of Gum on Gears
- Clutches do Not Bind - useful life more than doubled

*Report on actual installation

**Briggs Coolant Filters and Oil Clarifiers quickly pay for themselves in increased production and reduced maintenance . . . as this actual report clearly shows. What it doesn't show however, is the better work produced . . . closer tolerances, better finish. It doesn't show that the danger of dermatitis was minimized.**

**Effective filtration of coolants or lube oil may be the solution to your production and maintenance problems. Briggs Filters are available for unit machines, central systems or special applications . . . for all types of coolants and oils.**

**Get in touch with the Briggs distributor nearest you (listed in the "Filter" section of your Classified Telephone Directory) or write direct for complete descriptive literature.**

**Briggs**
PIONEERS IN MODERN OIL FILTRATION

**BRIGGS CLARIFIER COMPANY**
**General Offices, Washington 7, D. C. • Distributors in Principal Cities**

MANUFACTURING

CONTROL

THE KEY TO UNIFORM CARBIDES

THE art of manufacturing uniform cemented carbides requires the same "exceeding care" exercised by the talented research men who established the fundamental principles and practices of this highly specialized branch of metallurgical science. That is why Kennametal is subjected to precise control throughout every stage of its manufacture, by means of scientific instruments in the hands of skilled technicians. The objective of the chemical and metallurgical checks of processing is three-fold:

First, *to produce cemented carbides that will exactly suit predetermined requirements of differing character.*

Second, *to assure that the desired characteristics of finished products are uniformly maintained.*

Third, *to form the basis for continued research looking to still further improvement in the properties and applicability of Kennametal.*

● The invention and development of Kennametal—a scientific achievement—has led to corresponding useful arts. Kennametal's ability to cut hard metals with sustained accuracy, at greatly increased speed, has made major contribution to the technique of high production machining and milling. Its unique wear-resistant properties have created opportunity which many manufacturers have seized upon to give their products greater serviceability.

The technological advancements that accompany the use of Kennametal serve to suggest the tremendous potential benefits to society that are always inherent in a system, under which inventive genius is granted the rights, and given the means, to encourage full utilization of its talent.

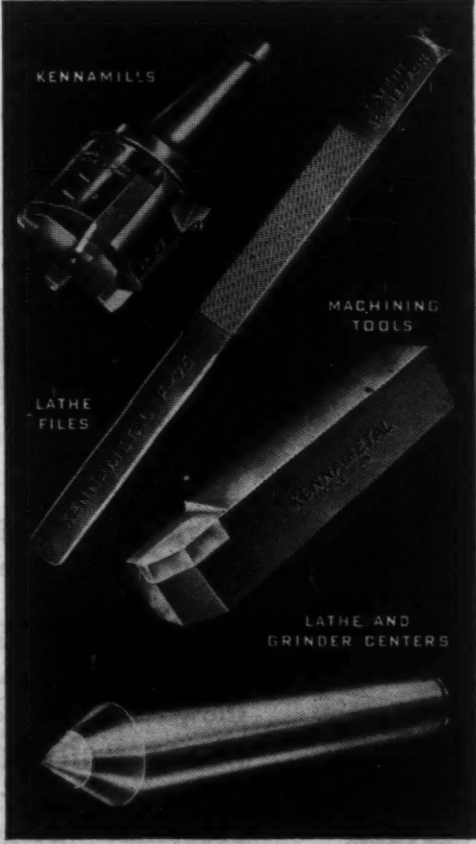
TRADE MARK REG. U. S. PAT. OFF.

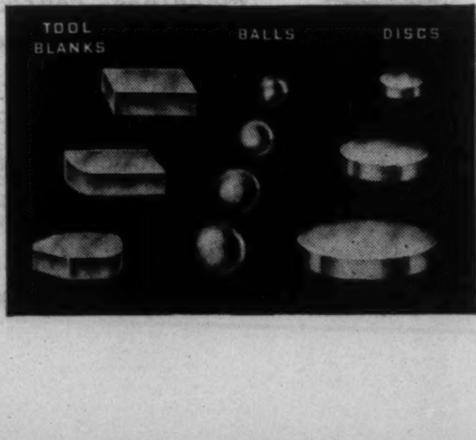
**KENNAMETAL**

SUPERIOR CEMENTED CARBIDES

KENNAMETAL *Inc.*, LATROBE, PA.

*Typical* **KENNAMETAL** *Products*





The manner in which steel is initially heated is important. High alloy steels have to be heated more slowly than carbon steels. Most ordinary steels can safely be charged in a furnace at 700 F. Three-quarters of an hour per in. of billet thickness will suffice for heating to about 1200 F.

The first step after the billet is properly heated is to work all surfaces lightly. This tends to close up any surface defects. Heavy blows may cause small seams.

To prevent cracking, high carbon or fairly high alloyed steel should be protected against rapid cooling, once the forging operation is finished. The forging should be buried in non-conducting material until its temperature has dropped to 200 F.

Mild or medium carbon forgings are seldom affected by hydrogen, nor are they easily injured by rapid cooling. Even in these cases, work should be protected against cold draft. All forgings except small and relatively unimportant ones made of low carbon steel should be heat treated after forging.

—M. B. Halpenny. *Can. Metals & Met. Inds.,* Vol. 8, Feb. 1945, pp. 20-25, 45.

## Rotating Hearth Furnaces

*Condensed from "Industrial Heating"*

A typical rotary hearth furnace installation is described. The hearth structure rotates on anti-friction bearing cast wheels that run on a circular rail track mounted as an integral part of the furnace superstructure. The hearth is driven by a variable speed motor drive through a circular rack mounted on the underside of the hearth structure. Operation may be continuous or intermittent. The drive unit allows a range of time in the heating chamber from 45 min. to 3 hr.

The combustion equipment is unusual, as it utilizes only one oil-fired proportioning oil burner firing down through the center of the arch into a circular combustion chamber located in the center of the rotating hearth. The flue gases are vented through the side walls at hearth level. This indirect firing offers excellent fuel ignition, prevents danger of flame impingement on the work, and permits a temperature range from 1100 to 1950 F. with good uniformity throughout this range.

The ability of these units to withstand the higher temperature has proven the value of using the alloy sand sealers and the cast alloy segmental angles for retaining refractories.

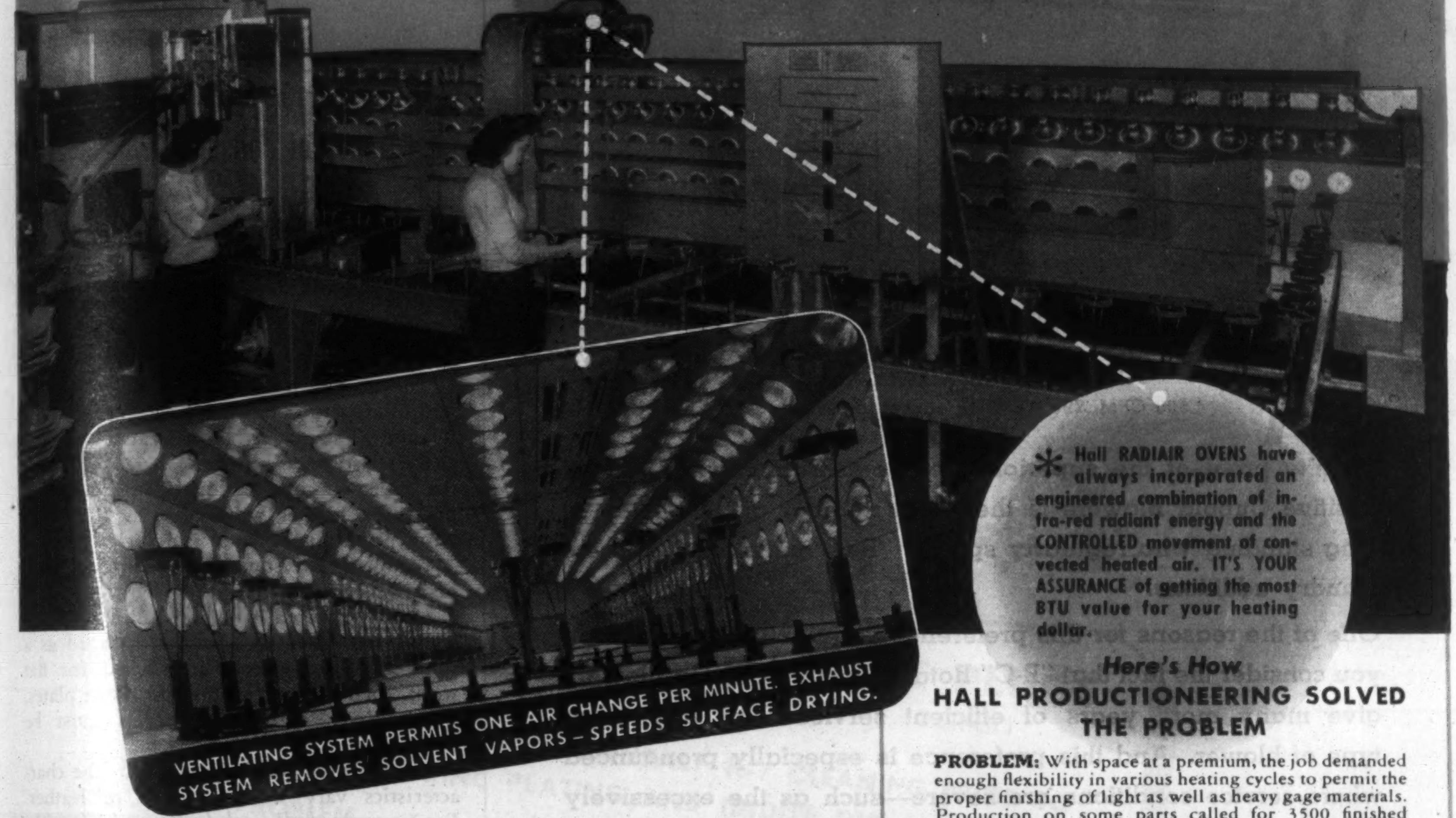
Other than mechanical wear on the charge and discharge door sill plate, no maintenance has been required and a shut down period has not been necessary in more than two years. The exceptional hearth life and fuel economy is attributed to the fact that the heating up and cooling down common to furnaces of other types is eliminated.

Rotary furnaces are increasing in popularity due to the wide operating temperature range, ease of operation, labor saving (one man does both charging and discharging), and ability to heat a wide variation in size of materials. The chief

ANOTHER C. M. HALL *PRODUCTIONEERED* RADIAIR OVEN APPLICATION

# *If Your Problem is:* PRODUCTION FINISHING LARGE QUANTITIES OF MISCELLANEOUS PARTS

# *Your Answer is:* A HALL *Radiair* INFRA-RED OVEN


VENTILATING SYSTEM PERMITS ONE AIR CHANGE PER MINUTE. EXHAUST SYSTEM REMOVES SOLVENT VAPORS—SPEEDS SURFACE DRYING.

*** Hall RADIAIR OVENS have always incorporated an engineered combination of infra-red radiant energy and the CONTROLLED movement of convected heated air. IT'S YOUR ASSURANCE of getting the most BTU value for your heating dollar.**

BECAUSE heating, drying and baking are vitally important in the production finishing of most war materiel—it is not surprising that infra-red with its numerous advantages has received industrywide acceptance and approval.

Yet, infra-red is not a cure-all. Like any other production process, it has its limitations. *Maximum time-and-money-saving advantages can only be obtained by its correct use in every application.* Because Hall RADIAIR Ovens are engineered on this basic principle the User invariably benefits through new and shorter heating cycles—improved methods of material handling—greater operating flexibility. The end point is always higher production at less cost.

For example, not long ago a war producer was faced with the job of drying and baking large quantities of miscellaneous parts ranging from plastic, rubber-coated rocket rings, to "windshields" for 105 mm and 75 mm shells. It was thought at first that a simple automatic spray operation, plus a run through any low temperature oven would answer the problem. But, there was a catch! The entire operation has to be handled in a space not much larger than an average good sized living room, with provisions made for a 3500 piece per hour capacity.

These requirements made the problem one for the book. Read to the right just how a Hall *Productioneered* application of infra-red solved the problem. Then remember to CALL IN HALL on your next drying, baking, preheating or dehydrating problem. You will not be obligated.

### *Here's How*
### HALL PRODUCTIONEERING SOLVED THE PROBLEM

**PROBLEM:** With space at a premium, the job demanded enough flexibility in various heating cycles to permit the proper finishing of light as well as heavy gage materials. Production on some parts called for 3500 finished pieces per hour.

**ANSWER:** The automatic spraying operation was made an in-line part of the overall oven layout. The materials handling system was designed to permit work to pass directly from spray booth into oven for three passes under infra-red radiant heating lamps.

**ADVANTAGES:** Faster drying, finishing and prolonged curing cycles that answered every flexibility demand. Variable control of lamp banks and conveyor speeds gives a wide range of work time in the oven extending from 3 to 7 minutes. BECAUSE OF THIS LONGER WORK CYCLE IN OVEN—OPERATING COSTS ARE HELD AT ROCK BOTTOM.

**AFTER THE WAR, *without alteration,* this same unit will be paying dividends in the efficient, low cost enamel baking of sealed-beam headlamp housings, headlamp shells, doors and other sheet metal stampings.**

**Learn what a *Productioneered* Hall RADIAIR Oven can save you in valuable finishing TIME—wartime minutes today—peacetime minutes tomorrow.**

SEND FOR YOUR COPY "Infra-Red at Work"

Infra-Red at Work

FOR INSTANT HEATING BAKING
C. M. HALL LAMP CO.
CONTROLLED HEAT
DRYING DEHYDRATING

## C·M·HALL *Lamp Company*

**PIONEER DESIGNERS AND BUILDERS OF INFRA-RED RADIANT HEATING EQUIPMENT**

**1015 EAST HANCOCK ST.**
**DETROIT 7, MICHIGAN**

REPEAT BUSINESS tells the story
1475
ROTARY POSITIVE

THE ABOVE INSTALLATION
4,500 CFM, 290 RPM, 16 ounces pressure

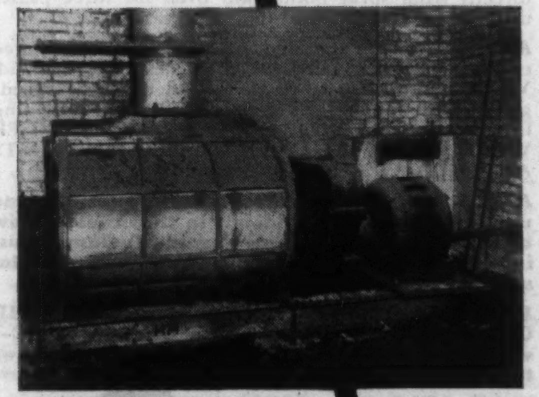
**Definite proof of the superiority of Roots-Connersville Rotary Positive Cupola Blowers is the great number of customers of long standing who regularly specify "R-C" units for their new foundry additions.**

**One of the reasons for this preference is quickly evident when you consider the fact that "R-C" Rotary Positive Cupola Blowers give many more years of efficient service than any other type of blower. And this preference is especially pronounced where service conditions are severe—such as the excessively dusty atmospheres encountered in some foundries.**

**Still going strong after 35 years**

**At left is shown a recent photo of a Roots Blower installed over 35 years ago in a foundry in Ohio. It is still in daily use and operating efficiently.**

**Photo at top of page shows an additional "R-C" Cupola Blower recently installed at this same foundry.**



**ROOTS-CONNERSVILLE BLOWER CORP.**
***ONE OF THE DRESSER INDUSTRIES***
**505 SUPERIOR AVENUE, CONNERSVILLE, IND.**

WRITE FOR BULLETIN 22-B-12

Roots CONNERSVILLE SINCE 1854
Rotary Positive CUPOLA BLOWERS

difficulties encountered in early designs have been overcome: namely, the method of firing has equaled the benefits of underfiring, and the difficulty of construction for the higher temperature is being overcome by the use of alloy sand seals, by allowances for greater expansion, and by keeping all moving parts an appreciable distance from the heat source.

—A. C. Kramer. *Industrial Heating*, Vol. 12, Feb. 1945, pp. 248, 250, 252.

## Types of Polishing Wheels

*Condensed from "Metal Finishing"*

The flexibility, resiliency, or degree of hardness of a polishing wheel is designated in the trade as its density. To describe its density, such terms as "hard," "medium," "soft," "super-soft," etc., are used. Control of density is a major manufacturing problem.

The terms "hard," "medium," or "soft" are difficult to define because they are only relative. The actual hardness and polishing characteristics of a wheel depend also on the type of construction. Thus, a "soft" bull neck leather wheel does not give the same performance as a "soft" cloth wheel.

Following are some of the different types of wheels in use:

Leather-covered wood polishing wheels. This is an older style, almost as hard as a solid grinding wheel. It is used for flat work, such as door plates and name plates, where sharp corners or bevels must be maintained.

Leather disk polishing wheels. The characteristics vary with the type of leather. For example, *bull neck leather wheels* withstand hard service and are used for polishing stove parts, hardened steel tools, forgings and some brass parts. *Walrus hide wheels* are available in single disk construction up to 1½-in. thickness. For thicker wheels, two or more disks are cemented together. Walrus hide is used for high quality finishes on cutlery and fine tools. *Full disk sheepskin polishing wheels* are flexible and soft, and are used for soft metals and jewelry.

Canvas disk polishing wheels. These are usually used with coarse heads for "roughing out" polishing operations or castings or forgings. They are used for initial or coarse polishing of agricultural implements, stove parts, etc., and for burring castings. By using different sewings and grades of canvas, a wide range of hardnesses are available.

Cloth or muslin polishing wheels. This is the most used type of wheel. By varying the sewing, the type of cement bonding the sections, etc., the hardness and flexibility can be widely varied. These wheels therefore find application all the way from "roughing out" to fine finishing. This type of wheel has a relatively low cost. A special off-set wheel in which the buff-sections run spirally rather than in parallel planes prevents "streaking" of the work.

Felt polishing wheels. These wheels possess a cushion with characteristics unlike any of the other materials. They are fast-

# Pennsalt EC-10 does a quick, thorough job

HEAVY GREASE OFF
EC-10
OILS OFF
EC-10
EC-10
SHOP DIRT OFF
EC-10
CHIPS OFF
CHIPS

**Oils, greases, metal chips and shop dirt are quickly removed from steel bomb fuse plugs in the precleaning process with Pennsalt EC-10. Pennsalt K-7 is used in the subsequent Anodic Cleaning process.**

**This combination makes it possible for each eight hour shift to produce an average of 9700 fuse plugs with only 1/10 of 1% rejects — a step up in production of 15%.**

**The following is the actual case history of this operation.**

## FUSE PLUGS
(BOMB)

### PENNSALT EC-10 AND PENNSALT K-7 CLEANING PRIOR TO ZINC PLATING AND IRIDITE DIP

**PROBLEM** To clean steel bomb fuse plugs free of oils, greases and filings prior to zinc plating and subsequent "Iridite" dip coating.

**EQUIPMENT USED** A 200 gal. solvent dip tank followed by a spray rinse and a 325 gal. reverse current alkali cleaning tank followed by a dip rinse tank.

**METHOD**

**PART 1 — PRECLEANING**

1. Use Pennsalt EC-10 concentrated, room temperature; soak for 30 seconds.
2. Cold water spray rinse.

**PART 2 — ANODIC CLEANING**

3. Use Pennsalt K-7 at 50 to 100 amps./sq. ft. at 8 oz./gal., 200° F. for 30 seconds.
4. Hot water rinse.
5. Muriatic acid dip.
6. Cold water rinse.
7. Zinc Electroplate.
8. Hot water rinse.
9. Hot "Iridite" dip and then dry air.

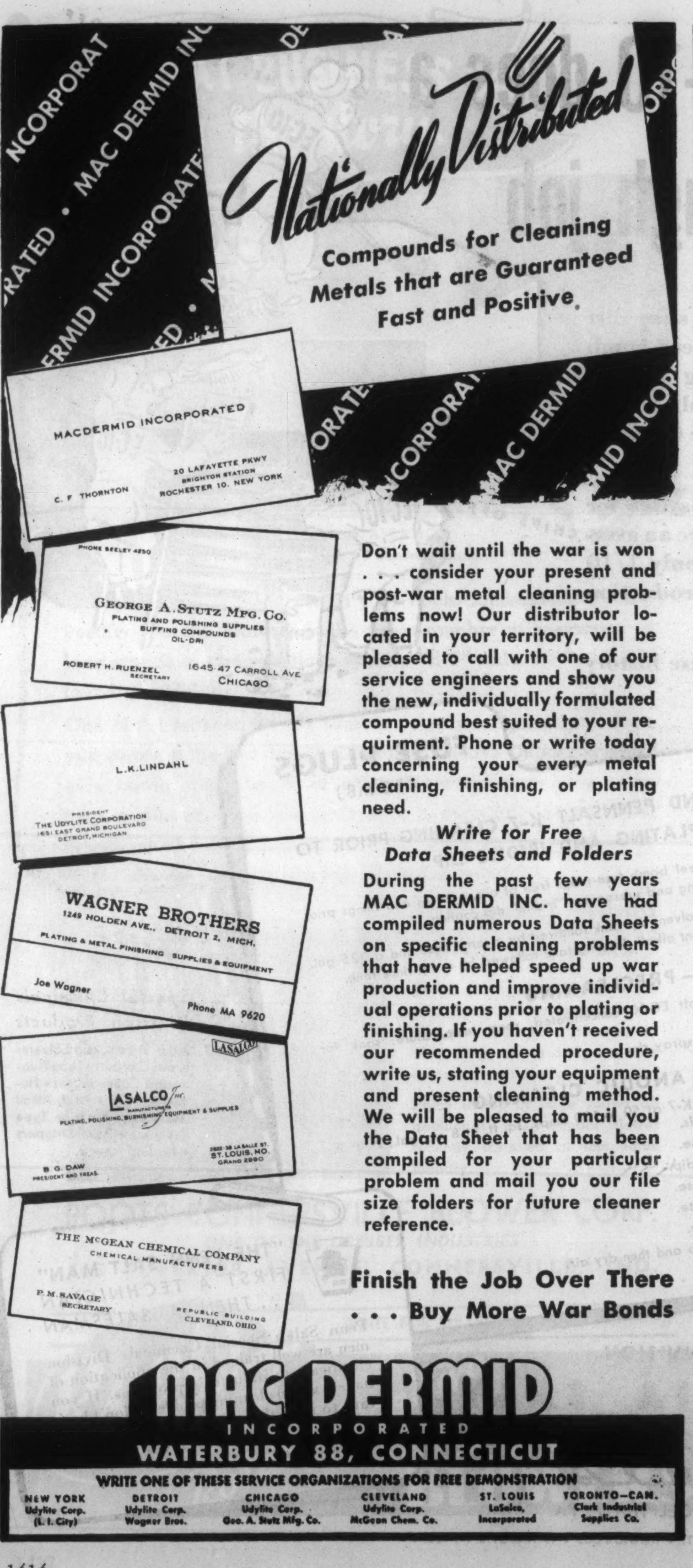
**Special Chemicals Division Products**

Acid-, Alkali-, and Solvent-proof Cements • Lead Fluoborate Concentrates • Fluoboric Acid • Acid, Alkali and Solvent Emulsion Type Cleaners • Paint Strippers • Pickling Agents.

**"THE PENN SALT MAN"**
**FIRST A TECHNICIAN**
**. . . THEN A SALESMAN**

Penn Salt's Special Chemicals Division men are well trained in the application of chemicals to industry's problems. If you have a metal cleaning problem, don't hesitate to seek the advice of "THE PENN SALT MAN." He will advise you without obligation.

SPECIAL CHEMICALS DIVISION
**PENNSYLVANIA SALT**
**MANUFACTURING COMPANY**
*Chemicals*
1000 WIDENER BUILDING, PHILADELPHIA 7, PA.
NEW YORK • CHICAGO • ST. LOUIS • PITTSBURGH • CINCINNATI • MINNEAPOLIS • WYANDOTTE • TACOMA



INCORPORATED • MAC DERMID INCORPORATED • MAC DERMID INCORPORATED

Nationally Distributed

Compounds for Cleaning Metals that are Guaranteed Fast and Positive.

MACDERMID INCORPORATED
C. F THORNTON
20 LAFAYETTE PKWY
BRIGHTON STATION
ROCHESTER 10. NEW YORK

PHONE SEELEY 4250
GEORGE A. STUTZ MFG. CO.
PLATING AND POLISHING SUPPLIES
BUFFING COMPOUNDS
OIL-DRI
ROBERT H. RUENZEL
SECRETARY
1645-47 CARROLL AVE
CHICAGO

L.K.LINDAHL
PRESIDENT
THE UDYLITE CORPORATION
1651 EAST GRAND BOULEVARD
DETROIT, MICHIGAN

WAGNER BROTHERS
1249 HOLDEN AVE., DETROIT 2, MICH.
PLATING & METAL FINISHING SUPPLIES & EQUIPMENT
Joe Wagner
Phone MA 9620

LASALCO
LASALCO Inc.
MANUFACTURERS
PLATING, POLISHING, BURNISHING EQUIPMENT & SUPPLIES
B. G. DAW
PRESIDENT AND TREAS.
2622-38 LA SALLE ST.
ST. LOUIS, MO.
GRAND 2890

THE McGEAN CHEMICAL COMPANY
CHEMICAL MANUFACTURERS
P. M. SAVAGE
SECRETARY
REPUBLIC BUILDING
CLEVELAND, OHIO

**Don't wait until the war is won . . . consider your present and post-war metal cleaning problems now! Our distributor located in your territory, will be pleased to call with one of our service engineers and show you the new, individually formulated compound best suited to your requirment. Phone or write today concerning your every metal cleaning, finishing, or plating need.**

***Write for Free Data Sheets and Folders***

**During the past few years MAC DERMID INC. have had compiled numerous Data Sheets on specific cleaning problems that have helped speed up war production and improve individual operations prior to plating or finishing. If you haven't received our recommended procedure, write us, stating your equipment and present cleaning method. We will be pleased to mail you the Data Sheet that has been compiled for your particular problem and mail you our file size folders for future cleaner reference.**

**Finish the Job Over There . . . Buy More War Bonds**

MAC DERMID
INCORPORATED
WATERBURY 88, CONNECTICUT

WRITE ONE OF THESE SERVICE ORGANIZATIONS FOR FREE DEMONSTRATION

| NEW YORK | DETROIT | CHICAGO | CLEVELAND | ST. LOUIS | TORONTO—CAN. |
|---|---|---|---|---|---|
| Udylite Corp.<br>(L. I. City) | Udylite Corp.<br>Wagner Bros. | Udylite Corp.<br>Geo. A. Stutz Mfg. Co. | Udylite Corp.<br>McGean Chem. Co. | LaSalco,<br>Incorporated | Clark Industrial<br>Supplies Co. |

cutting, but have a resilience that does not permit deep scratches or gages by the abrasive grains. They are, therefore, used where some metal must be removed, but where a high "color" or lustre is desired. They are not recommended for roughing out work.

Compress polishing wheels. This type of wheel brought a precision tool to the trade. It consists of a metal hub and side plates that hold a compressed ring of selected pieces of leather or bias-cut canvas radially in its periphery or cushion. Selection of the cushion material, and variation in the length, thickness and compression of the pads permits wide variation, but close control, of cushion hardness, from super-soft to super-hard densities. It is therefore adaptable to any type of polishing operation. Another advantage is its ability to take and hold special contoured or formed faces without "mushing-out," or spreading.

—C. A. Lux. *Metal Finishing*, Vol. 42, Dec. 1944, pp. 739-742.

## Contour Forming Stainless Steel

*Condensed from "Modern Industrial Press"*

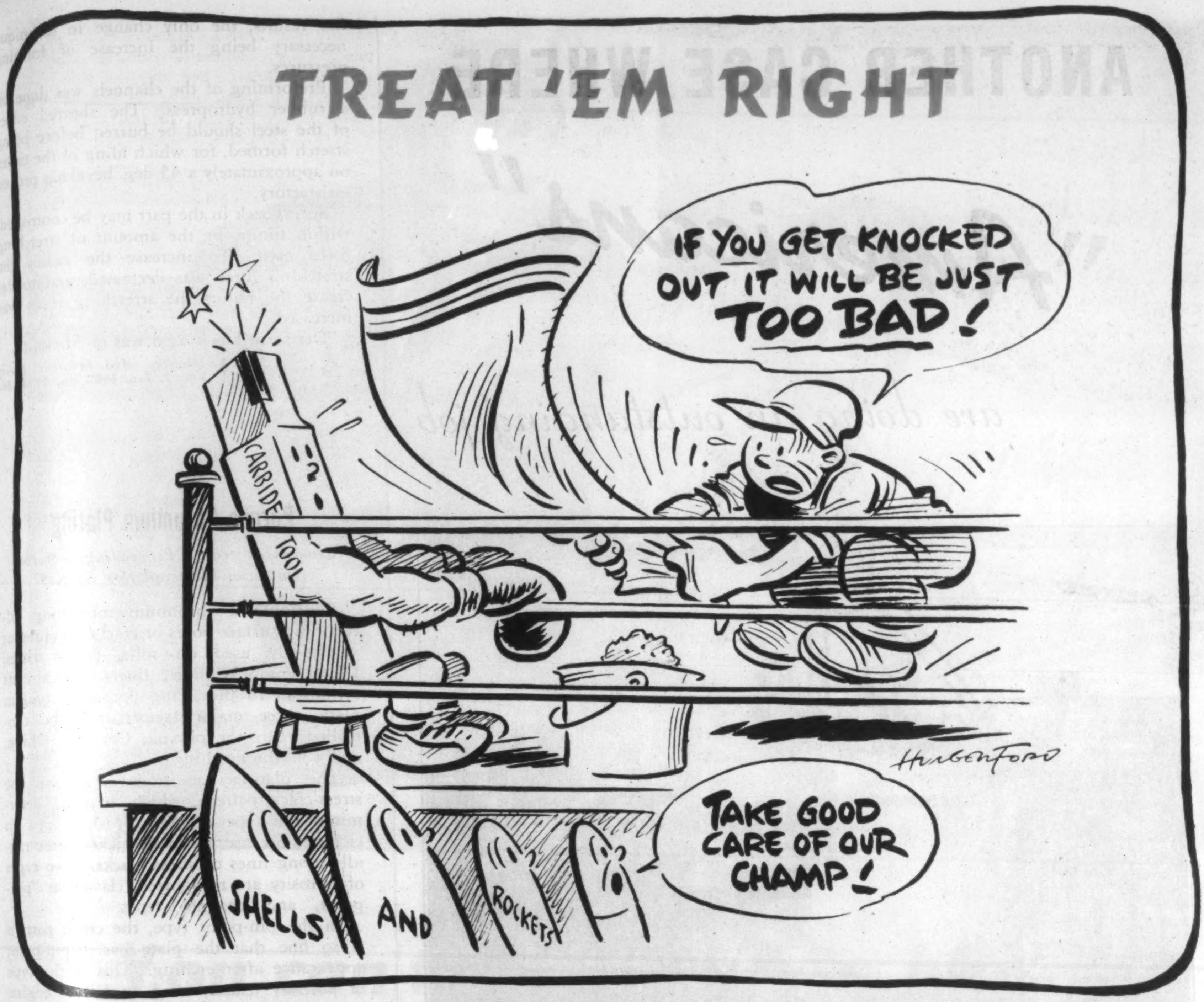
Forming an aircraft engine mount ring from stainless steel presented a difficult problem, since an assembly of curved channels was required. The channels could be built up, with the final ring taking the form of an I-beam curved into a circle. Bending of the material, 302 stainless steel ¼ H, presented difficulties, while the waste of material in cutting the web from sheet stock would have been excessive.

The design finally decided upon was to form two channels into half-circles by stretch-forming methods, and to spotweld these back-to-back to form half the I-beam ring. A flexible filler bar was inserted in the channel to prevent unwanted deformation, the form block was clamped with C-clamps to prevent lateral deflection, and the channel was formed under continually increasing pressure. Material used was 0.042-in. stainless steel, and the channel was 3.067 in. high, outside dimension.

An initial force of 18,700 lb. was applied, and increased to a final of 22,100 lb. The forming machine used was the Hufford Stretch Machine. Pressures finally fixed upon as standard were the following:

| | *Gage Pressure* | *Forming Force* |
|---|---|---|
| Initial stretch | 1110 p.s.i. | 18,700 lb. |
| ¼ formed | 1150 p.s.i. | 19,550 lb. |
| ½ formed | 1200 p.s.i. | 20,400 lb. |
| ¾ formed | 1250 p.s.i. | 21,250 lb. |
| Fully formed | 1300 p.s.i. | 22,100 lb. |

For experimental purposes, channels of 302 ½ H in the same thickness, 0.042 in., were stretch formed in the same manner. They were found to give surprisingly sim-


TREAT 'EM RIGHT
IF YOU GET KNOCKED OUT IT WILL BE JUST TOO BAD!
CARBIDE TOOL
HUNGERFORD
TAKE GOOD CARE OF OUR CHAMP!
SHELLS AND ROCKETS

## *Keep Your Carbide Tools in the Fight*

### CONSERVE THE TOOLS YOU HAVE!

If you follow a few simple rules now, you can avoid a critical tool situation in your plant. Handle all your present carbide tools with "kid gloves"—treat 'em right—and they will give better service, do all that is asked of them, and enable you to meet your greatly increased production schedules.

For practical information on how best to conserve your carbide tools and save delays, get in touch with Firth-Sterling.

### 3 RULES THAT CONSERVE TOOLS

**HANDLE 'EM WITH CARE**
Carelessness may damage cutting edges.

**KEEP 'EM SHARP**
Re-sharpen *in time!* A dull edge slows production.

**GRIND 'EM PROPERLY**
Find out the right way—and *do it.*

**Firth-Sterling**
**STEEL COMPANY**

**FIRTHITE**

OFFICES: McKEESPORT, PA. • NEW YORK • HARTFORD • PHILADELPHIA • PITTSBURGH • CLEVELAND • DAYTON • DETROIT • CHICAGO • LOS ANGELES

ANOTHER CASE WHERE

"Americans"

are doing an outstanding job

"AMERICAN" Electric Furnaces at SNOW-NABSTEDT GEAR CORP., New Haven, Conn., are meeting the close tolerances and exacting requirements of their War and Peace Time production.

ARMY E NAVY

The Model NA Air Tempering Furnaces and the Model B Furnaces for carburizing and hardening are shown above. Other AEF Furnaces are used for salt hardening.

**American Electric Furnace Company**
29 Von Hillern St., Boston, Mass., U. S. A.
*Industrial Furnaces for All Purposes*

ilar results, the only change in technique necessary being the increase of forming pressures.

Preforming of the channels was done on a rubber hydropress. The sheared edges of the steel should be burred before being stretch formed, for which filing of the edges on approximately a 45 deg. bevel has proved satisfactory.

Springback in the part may be controlled, within limits, by the amount of stretching force used. To increase the radius the stretching force was decreased, and to decrease the radius the stretching force was increased.

The form block used was of Masonite.

—Jack A. Johnson. *Mod. Industrial Press*, Vol. 7, Jan. 1945, pp. 33-34, 36.

## Porous Chromium Plating

*Condensed from "Proceedings" of the American Electroplaters' Society*

Electroplated chromium containing oil-retaining surface pores or cracks is at present extensively used on rolls, piston rings, Diesel engine cylinder liners, and aircraft cylinders. In producing porous chromium plate, three major factors must be controlled: (1) the plating, (2) the etching, and (3) the finishing.

The plating conditions determine the stress-crack pattern, which, in turn, determines the type of porosity developed in etching, because the plate etches most rapidly along lines of stress cracks. Two types of porosity are recognized, classed as "pin-point," and "channel" types.

In the pin-point type, the crack pattern is so fine that the plate has a pin-point appearance after etching. This is the type of porosity usually used on Diesel engine cylinder liners and on piston rings. In the channel type, the cracks are relatively widely spaced, so that after etching, irregular plateaus of chromium remain, bounded by open cracks. This type is used for aircraft cylinders.

Cracks are described as "primary," "secondary," etc. Primary cracks are open cracks, while secondary and tertiary are healed-over cracks at varying depths beneath the surface of the plate. A standard chromic acid plating bath is used usually with 250 g. per l. $CrO_3$, and with the $CrO_3/SO_4$ ratio between 100 and 125 per l. $CrO_3$ concentration and current density have little effect on the size of the crack pattern.

The size of the pattern increases with increase in the $CrO_3/SO_4$ ratio and with increase in temperature. Temperature is the most critical factor. A temperature of 122 F. is usually used when pin-point porosity is desired, and 140 F. for producing channel type porosity.

After plating, the porosity may be developed by chemical etching in an acid solution, *e.g.*, hydrochloric acid, by anodic etching in chromic acid solution, or by cathodic etching in hydrochloric, sulfuric, phosphoric, or oxalic acid. After etching, a mechanical finishing operation is applied (honing, lapping, etc.), in order to remove jagged surface protuberances and leave a

# You can't find it all in books!

GRINDING has become an exact science. And so, much of the standard information users of abrasives need to specify the right abrasive for the job *can* be found in the books—notably "GRINDING FACTS" by "CARBORUNDUM." Nevertheless, industrial grinding techniques advance so fast these days, the books can't quite keep up. If you have an abrasive problem that cannot be solved by the standard pattern, call a "CARBORUNDUM" Representative. He has access to the latest information from other users and from the "CARBORUNDUM" laboratories.

And there are always the "CARBORUNDUM" Abrasive Engineers. These are the men who know abrasives and their uses from the inside out. They have helped originate many of the present-day standard grinding techniques. They can sit right down with you at the planning stage and help you work out your problems from the start, as they have done for many manufacturers. For the solution to all your abrasive problems consult your "CARBORUNDUM" Representative. He will be glad to be of service. Write to The Carborundum Company, Niagara Falls, New York.

THERE IS A PRODUCT BY

**CARBORUNDUM**

TRADE MARK

FOR EVERY ABRASIVE APPLICATION

("CARBORUNDUM" is a registered trade mark of and indicates manufacture by The Carborundum Company) good running surface. All three operations must be carefully controlled in order to end with the proper plate thickness, the proper type of porosity, the correct ratio of channel to bearing area, etc.

Mechanical methods for producing porosity, *e.g.*, sandblasting of the basis metal, are also used.

—T. G. Coyle. *Proc.*, Am. Electroplaters' Soc., June 1944, pp. 20-75.

## Grinding with Diamond-Charged Mandrels

*Condensed from "American Machinist"*

A diamond-charged mandrel will increase the efficiency of stock removal in holes smaller than 1/4 in. diam., and makes possible the grinding of holes 0.030 in. or less in diam., unattainable with a conventional mounted wheel. The process is faster and cheaper than grinding with abrasive wheels or points for holes up to 1/4 in. For larger holes, the mandrel would be too stiff for truing and, anyway, the wheel is easily dressed and can be run at proper peripheral speed.

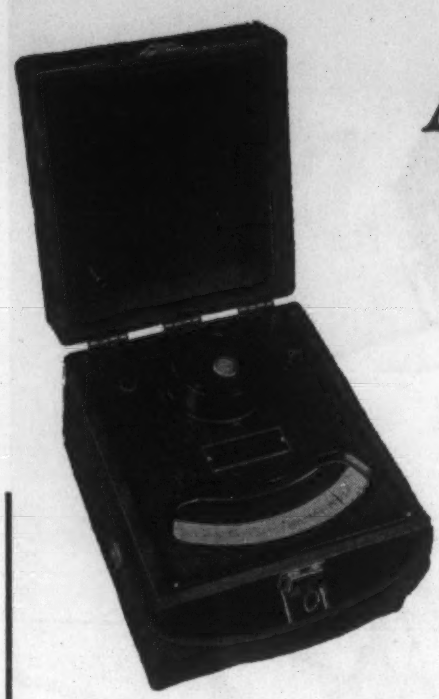
The mandrels may be used, first, in gage work, where holes can be cleaned up to within 0.0002 to 0.0004 in. Then the grinding ridges are removed by lapping so that the gage possesses maximum wear quality. If gage holes were ground to final dimensions, the ridges would soon be flattened by repeated insertion of a plug gage and the gage's accuracy lost. Second, in die work the holes can be ground to final dimensions, because the grinding ridges serve to retain die pins.

"Diamond grinding" is not "diamond lapping." Grinding wheel action is like that of a multi-point boring tool, while a lap resembles a reamer in action. The advantages of the diamond-charged mandrel over an abrasive wheel for small holes lie in the reduced s.f.m. requirement (about one-fourth that of a grinding wheel), its greater rigidity due to its homogeneous structure and the improved cutting action of a diamond dust as an abrasive. It is more economical, both as to cost of preparation and unit cost of stock removed, than the mounted grinding wheel.

One must use the correct size of diamond particles. A coarse grade of 60-80 grit should be used for roughing operations on holes of 3/32 in. diam. or larger, while 80-100 grit is needed for finishing mandrels for this range of diameters and is used for roughing and finishing on holes less than 3/32 in. diam.

A small quantity of diamond dust is placed on a hardened steel (Rockwell C 65) plate moistened with light oil. The surface to be charged is placed in the dust and tapped sharply with a hammer, also hardened to Rockwell C 63-65. Meanwhile, the mandrel is turned slightly to expose its entire surface to the dust. Hold the mandrel about 1/8 in. from the block so that diamond particles are driven into both sides of the mandrel. This firmly embeds the particles without the crushing or pul-

INSTANTANEOUS ACCURACY



with

**ENGELHARD**

Portable Indicating Pyrometers

**Engelhard Portable Indicating Pyrometers combine the necessary attributes of accuracy and instancy which distinguish the completely efficient precision instrument.**

**High resistance per millivolt assures a degree of accuracy unaffected by connecting lead length or by thermocouples of different resistances.**

**Direct deflection construction permits instantaneous readings easily in either millivolts or degrees.**

**The conveniently portable instrument is a complete unit in a sturdy carrying case with removable cover.**

**The 6" scale length indicator may be calibrated with 100 to 150 divisions. Scale range may be selected to suit specific applications. Every indicator is equipped with the Engelhard frictionless moving coils.**

**All indicators may be furnished with two scale calibrations —for rare metal and base metal thermocouples. By a simple change of lead connections readings are made on either scale.**

***WRITE FOR BULLETIN 28315-R***

CHARLES ENGELHARD, INCORPORATED
90 CHESTNUT ST., NEWARK, NEW JERSEY

**DESIGNED SPECIFICALLY FOR AC WELDING of CAST IRON**

*Announcing a New*

# P&H "HARCAST"

## Entirely New . . . Entirely Different!

● Perhaps you've wondered why such an all-around electrode for welding cast iron was not available. So did P&H research engineers. And they went to work on it!

It took nearly three years. But now it's ready . . . ready to end your worries about weld cracks, poor penetration, excess porosity or pulling away at the fusion zone. It produces sound, dense welds with a tensile strength of 60,000 lbs. p.s.i.— approximately twice that of a good grade of cast iron. And it fuses well with mild or medium carbon steels for joining to cast iron.

### Can Be Used at Low Amperages

Low amperage welding with "Harcast" minimizes the dilution at the fusion zone, improves machining qualities. It's easy to use, too, for single or multiple pass work. But its operating characteristics are entirely different.

### An All-position Electrode — for Both AC and DC Welding

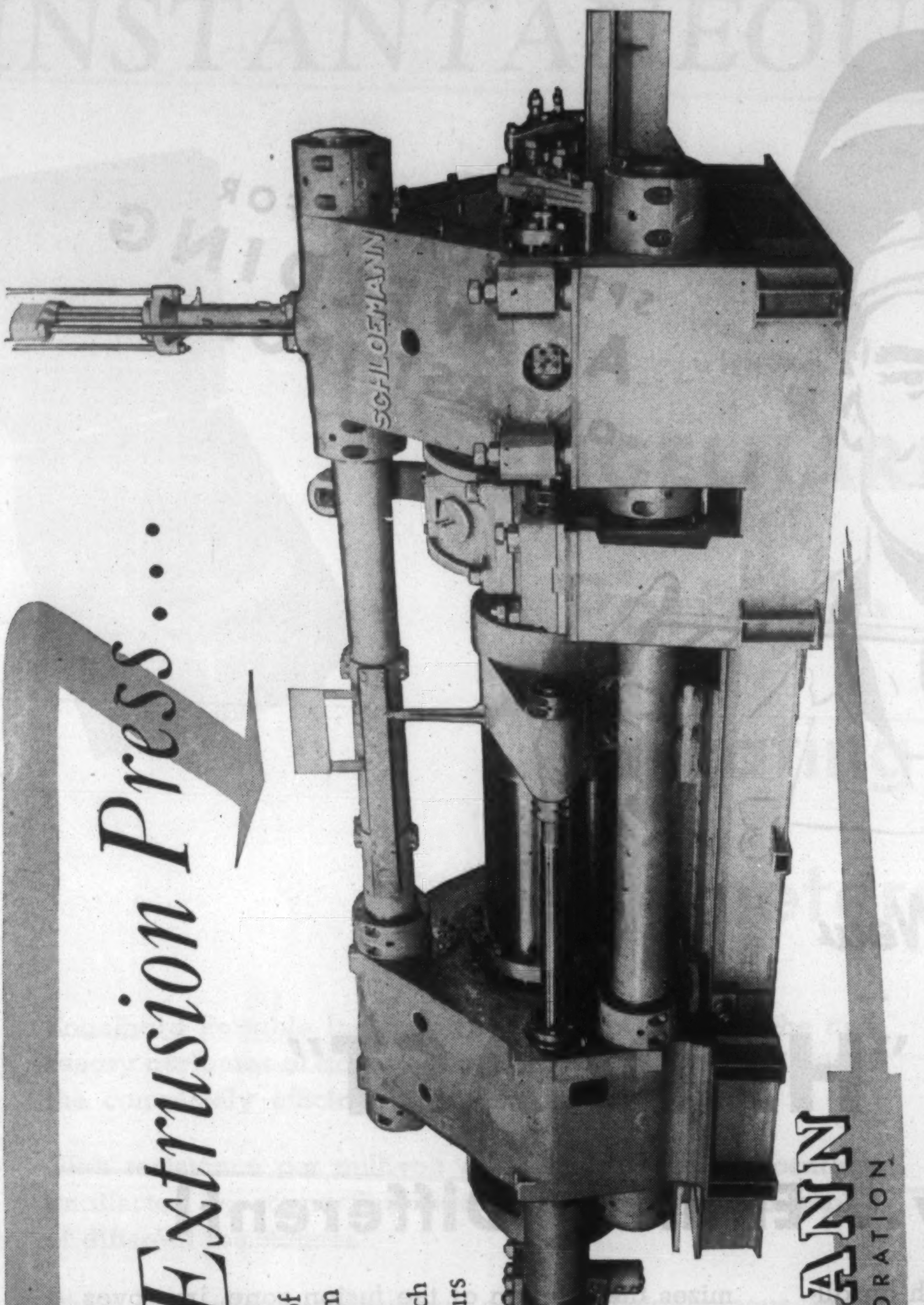
You can use P&H "Harcast" in all positions; downhand, vertical or overhead. Although designed primarily for AC welding, it works equally well on DC. But why not get full information? Try it yourself and see the difference! Write for literature.

**A COMPLETE ARC WELDING SERVICE**

DC Welders · AC Welders · Welding Electrodes · Welding Positioners · Welding Control Systems · Electric Hoists · Electric Cranes

P&H WELDING ELECTRODES
4550 W. National Avenue,
Milwaukee 14, Wis.

HARNISCHFEGER CORPORATION
HOISTS · WELDING ELECTRODES · MOTORS · P&H · EXCAVATORS · ELECTRIC CRANES · ARC WELDERS



**This 2500 TON**
*Schloemann Rod Extrusion Press...*

. . . was engineered and designed for efficient extrusion of bars, rods, all types of sections, wire rods and strip from aluminum, magnesium, copper and steel alloy billets.

The metal is shaped to highly accurate dimensions. Each press is built to endure extreme runs of tonnages and hours at low operating and maintenance costs.

**OTHER PRODUCTS**
- HYDRAULIC PRESSES
- COMPLETE HYDRAULIC SYSTEMS
- AIR HYDRAULIC ACCUMULATORS
- ACCUMULATOR CONTROLS

**SCHLOEMANN**
ENGINEERING CORPORATION
1104 EMPIRE BLDG., PITTSBURGH 22, PA.
HYDRAULIC PRESSES • ROLLING MILL MACHINERY

verizing effect found when the surface is rolled between two plates. After charging, the mandrel should be dipped in acetone to remove adhering oil.

Olive oil or other lubricants should not be used when diamond grinding, as they tend to glaze and load up. The surface of mandrel and hole is kept clean and dry. Caution should be used in re-charging a mandrel just as a hole approaches size because the rate of stock removal will increase greatly over that of a worn mandrel.

—F. C. Victory. *Am. Machinist*, Vol. 89, Feb. 1945, pp. 107-110.

## Forging on a Spot Welder

*Condensed from "Steel"*

A number of unusual forging and welding jobs are being handled in Sciaky resistance welders, which provide variable pressure and current cycles under precise automatic control.

An example is the forging of the heads of ½-in. diam. clevis pins. Heading dies to form the ends of the pin were made, and these act as the electrodes of the welder when doing this work. A preheat current is applied for 2.55 sec., followed by the main heating shot applied for 1.2 sec.

The three-phase-to-single-phase welder used first converts standard three-phase 60-cycle current to direct current by means of rectifier tubes. This direct current is then reconverted to single-phase alternating current at frequencies of 3 to 25 cycles per sec.

Half waves 1/15 sec. long and spaced 1/6 sec. apart are used to form impulses. The root-mean-square value of each current pulsation is about 25,000 amp. during the 1.2-sec. period. This allows the heat developed to penetrate into the body of the work.

At the start of the work cycle, a rather high pressure is used to break up any scale on the pieces at the points where they contact the electrodes, and this pressure is maintained during preheating. The pressure is then reduced and held at a lower value during the main heating period. Then maximum pressure of 2540 lb. is applied for three sec. to forge the head.

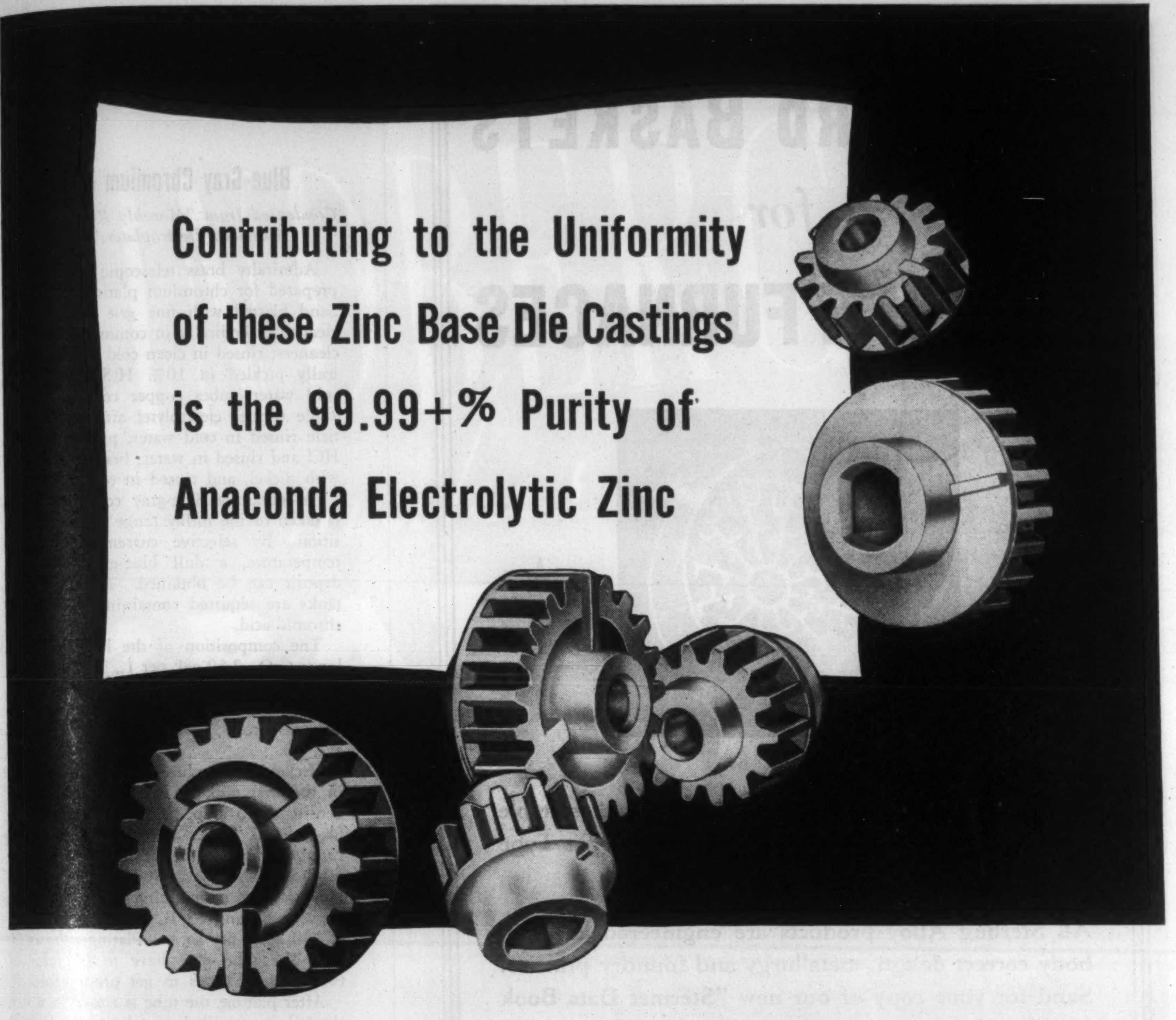
These current and pressure cycles are controlled by electronic timers. A great variety of current and pressure cycles can be applied. Two preheat values, a main heating value, and two postheat values can be set up for obtaining almost any desired combination.

Another application is forge welding 3/16-in. diam. pins through a 3-in. disk. The upper electrode is hollowed out to receive the pin and contacts pin only at upper end. As current is applied, the lower end of the pin extending through the disk becomes heated rapidly, mushrooms out to fill the counterbore, and then a heavy "slug" of current welds the entire assembly together.

Angle sections used to reinforce the panels are now spot welded instead of plug welded as formerly, saving a great deal of production time. Hinges are also being spot welded to doors on the heavy duty

*(Continued on page 1424)*

# Contributing to the Uniformity of these Zinc Base Die Castings is the 99.99+% Purity of Anaconda Electrolytic Zinc



MOST WIDELY USED of all die casting metals, zinc base alloys offer the parts or product manfacturer measurable advantages in production, finishing and die costs. Zinc base die castings are easiest to cast. They can be produced in intricate detail, greater size, and complexity of design.

Combining strength with minimum sectional thickness, zinc base alloys emerge smooth from the dies—are easily machined and finished. The overall cost per piece is usually lowest.

Zinc base alloy quality and uniformity depend in large measure on the purity of the zinc used. When Anaconda Electric Zinc, guaranteed 99.99+ percent pure is specified, the production of high quality zinc base die castings is safeguarded.

44309

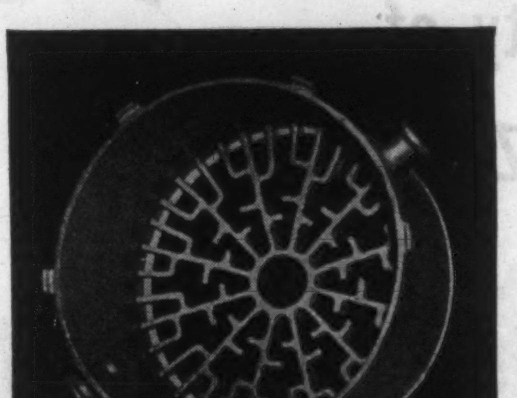
BUY WAR BONDS
. . . Let's make it our business

TRADE MARK
AN ACON DA
MADE IN U.S.A.
EL ECTR IC
REG. U.S. PAT. OFF.
99.99

**ANACONDA SALES COMPANY**
**25 BROADWAY, NEW YORK 4, N. Y.**
***Subsidiary of Anaconda Copper Mining Co.***

COPPER • ZINC • LEAD • SILVER • CADMIUM • BISMUTH • ARSENIC

STANDARD BASKETS
*for*
PIT TYPE FURNACES



★ ★

**We have a variety of patterns for baskets suitable for handling various kinds of work loads in Pit Type Furnaces.**

**All Sterling Alloy products are engineered and embody correct design, metallurgy and foundry practice. Send for your copy of our new "Stermet Data Book No. 200."**

*District Engineering Offices*

DAYTON
A. F. Tenney
132 N. Main St.
Fulton 1866

LOUISVILLE
G. Dell
214 N. Bloom St.
Magnolia 7824

PORTLAND, ORE.
A. C. Wooley
Terminal Sales Bldg.
ATW. 4107

NEW YORK CITY
R. B. Steele
254 West 31st St.
Long. 5-5296

DETROIT
C. C. Miller
8186 Livernois Ave.
Tyler 5-3338

ST. LOUIS
J. Sonnenfeld
9 Westwood Forest
Terry. 33108

PHILADELPHIA
Thomas J. Donovan, Jr.
1615 N. 2nd St.
Regent 4616

BUFFALO
W. G. Merowit
436 Niagara St.
Madison 1233

CLEVELAND
E. F. Kraft
609 Caxton Bldg.
Main 3651

HOUSTON
D. L. Glidden
Engineering Co.
1st Nat'l. Bank Bldg.

CHICAGO
Harry N. Steffen, Jr.
4821 W. Cortland St.
Berkshire 7669

PITTSBURGH
John N. Berger
1200 Standard Life Bldg.
Atlantic 5476

MILWAUKEE
E. W. Bock
4105 N. Newhall St.
EDG. 9061

SPRINGFIELD, MASS.
Associated Engineers
83 State Street
Tel. 4-4973

"ALLOYS that work while they're HOT"

STERLING ALLOYS, Inc.
WOBURN, MASS.

machine. While 20,000 p.s.i. on shear tests is specified, actually values up to 36,000 p.s.i. are obtained.

—G. W. Birdsall. *Steel,* Vol. 116, Feb. 19, 1945, pp. 106-107, 146, 148, 151-152.

## Blue-Gray Chromium Plating

*Condensed from "Monthly Review" of the American Electroplaters' Society*

Admiralty brass telescopic antennae are prepared for chromium plating as follows: Sand blasted with fine grit (120); tubes cleaned cathodically in commercial alkaline cleaners; rinsed in clean cold water; cathodically pickled in 10% $H_2SO_4$; rinsed in cold water; tubes copper coated from cyanide copper electrolyte; after plating, article rinsed in cold water, pickled in 10% HCl and rinsed in water; brass tubes plated with nickel, and rinsed in cold water.

To obtain a blue-gray color, advantage is taken of the milky range of electrodeposition. By selective current density and temperature, a dull blue-gray chromium deposit can be obtained. Two chromium tanks are required containing 400 gal. of chromic acid.

The composition of the bath is as follows: $CrO_3$, 2.50 gal. per 1., 33 oz. per gal.; $H_2SO_4$, 2.50 gal. per 1., 0.33 oz. per gal. The critical temperature is 80 to 90 F.; the current density, 150 amp. per sq. ft., voltage, 12.

Nickel-coated tubes are chromium plated in the first tank for 20 sec. at a current density of 15 amp. per sq. ft., temperature 88 to 90 F. Tubes are then placed in cold running water. In the second tank, the color of the deposit is controlled to a uniform blue-gray by maintaining the temperature between 80 and 85 F., and current density at 150 amp. per sq. ft. Plating time is 20 sec. The tube may have to be returned two or three times to get proper color.

After plating, the tube is rinsed in water, cleaned in an alkaline solution and dried in a steam box. Finally it is greased with petrolatum and wiped dry. The required apparatus includes two generator sets and two rectifiers. A total of 6000 amp. or 72 kw. are required.

—Albert Hirsch. *Mo. Rev., Am. Electroplaters' Soc.,* Vol. 32, Feb. 1945, pp. 119-121.

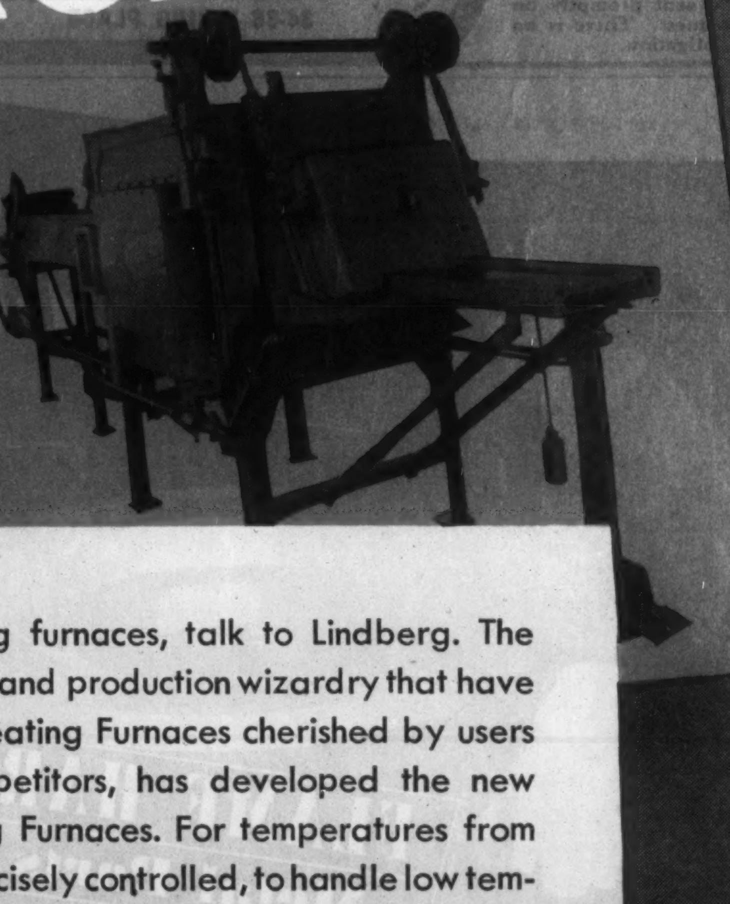
## Phosphate Coatings in Wire Drawing

*Condensed from "Wire and Wire Products"*

Wire mill superintendents have found that phosphate coatings on ferrous rods and wire give longer die life, greater rust resistance and other advantages at a very slight increase in cost. The phosphate coatings cause practically no change in dimensions and weight. The appearance of the rod or wire is only slightly different from that of clean pickled steel.

The complex ferrous and ferric phosphates form a tenacious parting layer that serves as an added lubricant in drawing, and absorbs the usual die lubricants. The coating is fine grained and tightly adherent so that it withstands the deformation involved in drawing.

# LINDBERG *makes* BRAZING FURNACES



When you want brazing furnaces, talk to Lindberg. The same engineering genius and production wizardry that have made Lindberg Heat Treating Furnaces cherished by users and respected by competitors, has developed the new line of Lindberg Brazing Furnaces. For temperatures from 1300° F. to 2500° F., precisely controlled, to handle low temperature silver brazing, high temperature copper brazing, powder metallurgy, bright annealing, general tool hardening, high speed tool hardening. Write for full information.

**LINDBERG ENGINEERING COMPANY**
**2451 WEST HUBBARD STREET, CHICAGO 12, ILLINOIS**

SUPER—WETTING
KWIKFLUX
SPEEDS PRODUCTION

Fast Flowing . . . No Lumping or Pitting of Solder
MEETS ALL RIGID SPECIFICATIONS

KWIKFLUX accomplishes 25% to 50% higher wetting action than the fluxes now on the market, and has almost 100% higher penetration in deep joints. It works perfectly with direct gas flame, hydrogen, acetylene—Muffle (direct or indirect) and induction heating.
KWIKFLUX is used for brazing, hard soldering and welding of Stainless Steel, Iron, Copper, Brass, Bronze, Platinum, Gold, Silver, Monel Metal, Nickel, German Silver and other ferrous or non-ferrous metals and alloys. It will not blacken brass or copper, and is suited to either automatic or manual operations. Fast, efficient action assures improved quality and finish.

OUR NEW 1945 PRICE SCHEDULE PLACES KWIKFLUX ON AN ALL-INCLUSIVE COMPETITIVE BASIS

*Advantages:*
(1) Perfect with both Low and High Melting Point Hard Solders.
(2) Excess Flux washes off clear in hot water—saves cleaning and finishing time.
(3) Does not lump or pit solder. Forms smooth film easily washed off, leaving surface beneath bright and shiny.
(4) Faster, Fluxing Actions—saves time, gas and electricity.
(5) Fumes are fixed because KWIKFLUX is neutral. Increases production efficiency.

*SEND FOR FREE TRIAL JAR*
For more than 12 years, our tested research improvements have been passed on to our customers. This service has been in operation during the war period.

TESTED AND PROVEN BY PROMINENT USER OF FLUXES
"KWIKFLUX has proven far superior to other fluxes due to the ease with which the excess material may be removed after brazing, that it is also necessary to use very much less quantity, and that it is much easier on the eyes, throat and hands." (Name on request)

WRITE FOR LITERATURE
Data sheets describing KWIKFLUX in detail — advantages, properties, characteristics and price—will be sent promptly on request. There is no obligation.

KWIK FLUX
(Patented)

SPEC
SPECIAL CHEMICALS CO.
34-36 IRVING PLACE NEW YORK 3, N. Y.

Can this Skill help YOU?
FLAME HARDENING
Metal Parts at their Points of Wear

Flame Hardening • Annealing • Aerocasing • Carburizing
Bar Stock Treating and Straightening • Heat Treating
Nitriding • Cyaniding • Physical, Tensile and Bend Tests.

MASTER CRAFTSMEN
METAL TREATING INSTITUTE

THE LAKESIDE STEEL IMPROVEMENT CO.
5418 Lakeside Avenue CLEVELAND, OHIO Phone Henderson 9100

A welded black iron tank is used for the coating solution, which contains 2 to 4 oz. of the coating solution per gallon of water. The temperature of 140 to 160 F. is very important, since it determines the pH, which appears to be the controlling factor in regard to the size of the crystals in the phosphate coating. Unless the crystals are small, the coating will not be sufficiently adherent.

The rods or wire are pickled, rinsed, submerged in the phosphate coating solution for 8 to 10 min., rinsed, dried, limed and baked as usual. The weight of the coating is about 100 mg. per sq. ft. When the dragout is taken into consideration, the cost of the coating is about 10 cents per ton of #1 rods.

The phosphate coating is not only rust resisting but also non-hygyroscopic. Its remarkable adherence is shown by the fact that it is still visible after 7 holes of dry drawing or 10 to 12 holes of wet drawing. The coating holds the oil by absorption on the surface. Actual tests show that a heavy phosphate coating has the ability to retain more oil than clean iron or steel or than a thin phosphate coating. Soaps used in drawing may be absorbed just like oils.

The appearance, uniformity and quality of the wire drawn with a phosphate coating are excellent. Moreover, die life is increased and there is less down-time of the dies so that deliveries are likewise improved.

—V. D. Smith. *Wire & Wire Products,* Vol. 20, Feb. 1945, pp. 121-123.

## Hyper Milling vs. High-Speed Milling

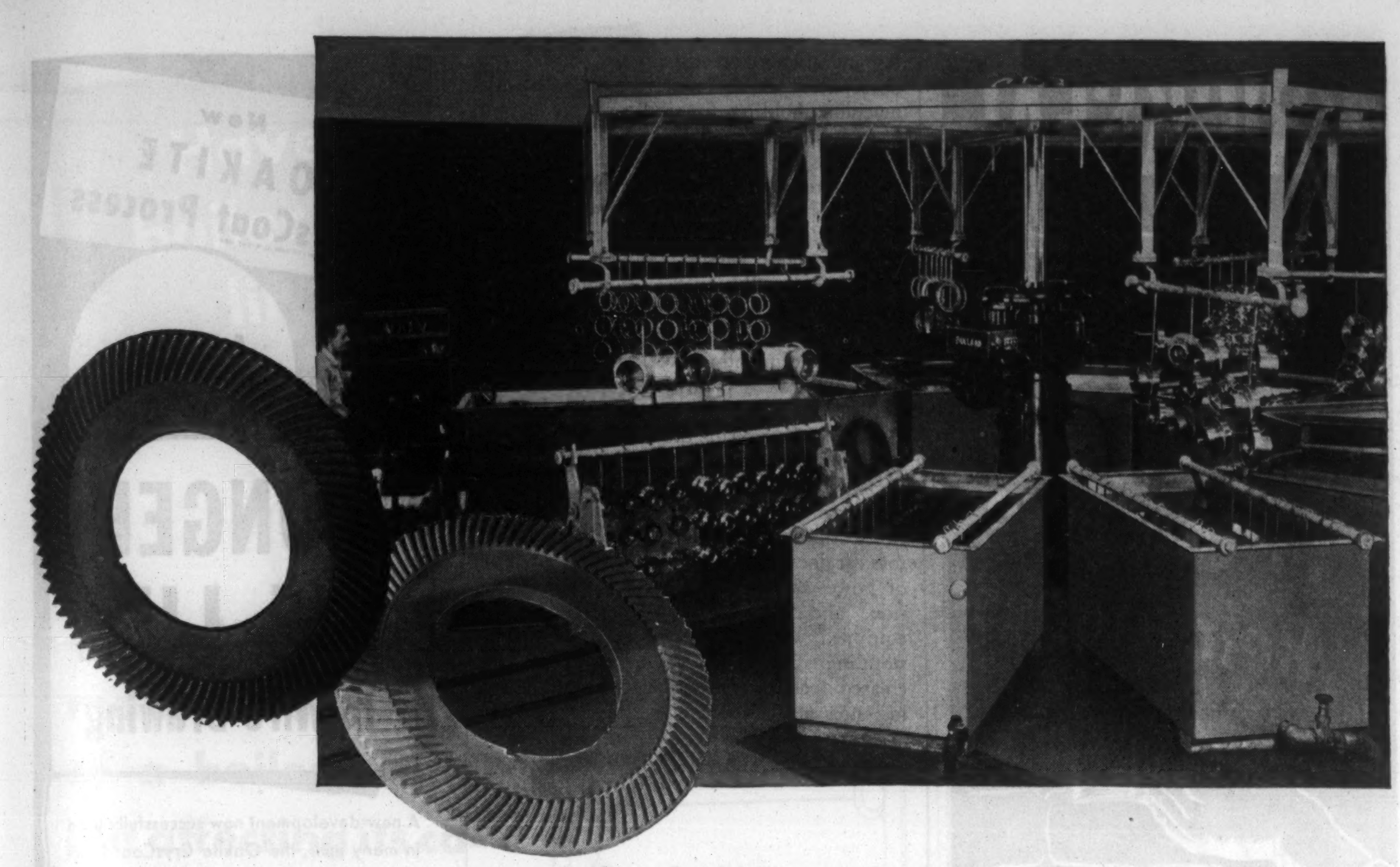
*Condensed from*
*"Western Machinery and Steel World"*

Use of hyper milling in the Lockheed shops has cut milling time on some jobs as much as 500 to 600%. Hyper milling is a technique, and does not end with the purchase of a machine. Speeds and feeds are of prime importance, and a thorough knowledge of correct chip-loading is necessary. Proper cutters, quick-operating holding fixtures, and properly flywheeled mandrels make the technique a mass production process.

Cutting speeds have been found to vary from 500 to 1000 s.f.m. High-speed milling, when governed by the same conditions, averages 40 to 100 s.f.m. Annealed and normalized chrome molybdenum steel can be cut at an average peripheral speed of 600 ft. When the same steel is heat-treated to 160,000 to 180,000 p.s.i., it is necessary to drop to about 350 ft. However, cold rolled free machining steels are milled at 1000 s.f.m.

Chip loading must be maintained for successful hyper milling, and varies from 0.003 in. to 0.020 in. per tooth. The average chip load at Lockheed is 0.010 in. per tooth, and the average feed is 10 in. per min. Similar cuts with high-speed cutters would have an average feed of 2 in. per min.

One of the commonest errors of operators new to hyper milling is in too low chip loading. The amount of loading is controlled by a number of factors, such as



THE *Only* WAY TO REMOVE SCALE AND OXIDE FROM FERROUS METAL

*. . . without attacking the work surface*

When dimensional changes are taboo, or when a really clean surface is needed, there is only one descaling method to use . . . the Bullard-Dunn Process.

This is the way it works. While the scale and oxide are being electro-chemically removed, a thin metallic film* is simultaneously deposited on the clean areas, protecting them against attack. This prevents attack 100%.

The process has exceptional throwing power. The scale removal and metal-film protection extend even into deep holes and recesses.

Bullard-Dunn is *fast* because it uses electric current (low voltage) . *economical* because material and labor cost is low . . . *practical* because it is easy to operate. It *expedites production* because it gives dependable, uniform, day-to-day service. Good equipment is available for both manually-operated and conveyorized units.

To demonstrate the many advantages of this process, we are always glad to treat representative samples of your work. Meanwhile, have us send you Bulletin TR-BD.

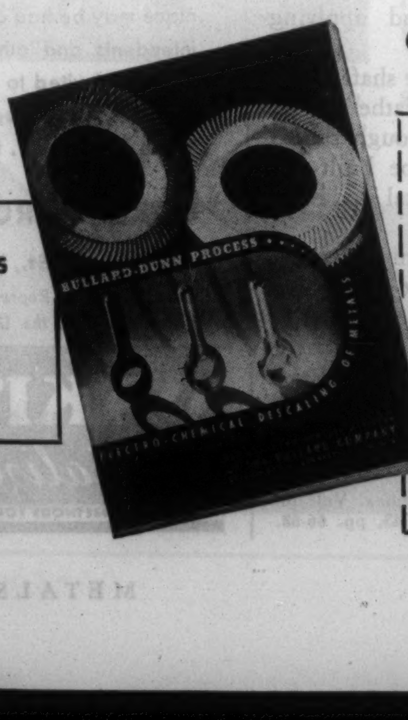
**WHEN TO USE THE BULLARD-DUNN PROCESS**

1. To remove scale completely for grinding, plating, inspection, etc.
2. To remove scale from work that cannot stand dimensional changes.
3. To clean out internal surfaces.
4. To clean and lubricate surfaces for hobbing or drawing.
5. To clean and provide base for soldering hot tinning or paint.
6. To clean rubber molds.

*This metallic film can be quickly and easily removed when a chemically clean work surface is desired.

*Only Bullard-Dunn descales without dimensional change*

**FOR FULL FACTS MAIL THIS COUPON TODAY**



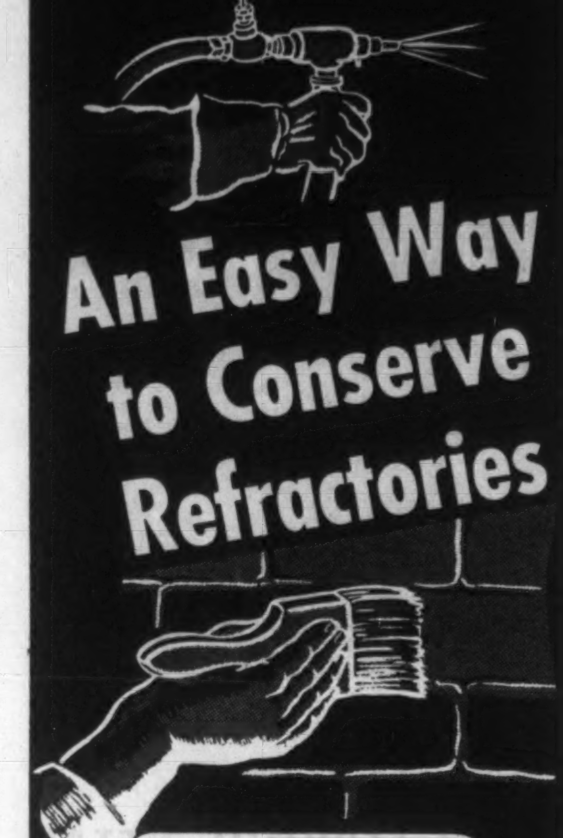
**THE BULLARD COMPANY, Bridgeport 2, Conn.**

Please send me Bulletin TR-BD describing the Bullard-Dunn Process.

Name ..............................................................

Company ..............................................................

Address ..............................................................



**BRICKSEAL**

**An Easy Way to Conserve Refractories**

1—*Paint or spray brickwork with BRICKSEAL.*

2—*Light fire. Furnace is ready for immediate production.*

**Heat of furnace vitrifies Brickseal permanently into all pores, cracks and joints, forming a highly-glazed, monolithic coating, impervious to acids, alkalis, corrosive gases, flame abrasion and air infiltration.**

**Brickseal will not crack or peel off due to sudden temperature changes, because it remains semi-plastic until the furnace cools. Brickseal prolongs the life of new or old refractories for a fraction of the cost of relining.**

**Write for Brickseal sample or representative, today.**

**BRICKSEAL**
**REFRACTORY CO.**
1029 CLINTON ST., HOBOKEN, N. J.

the number of teeth in the cutter, the horsepower of the motor, rigidity of the machine, holding fixtures, and the design of the part being machined.

Cutters used are in most cases cast Meehanite body with induction brazed carbide tips. Earlier machines were underpowered, and motors burned out, but newer machines are amply powered. Holding fixtures that will give the ultimate in quick loading and unloading are necessary to obtain full advantage of hyper milling. After experiments covering every type, Lockheed has standardized upon an air-operated fixture of its own design.

The leveling-off of the load accomplished by the use of flywheels is a distinct advance in hyper milling. The choice of flywheels is determined by the clearance available, the cut to be made, and other mechanical factors. It does not require a noticeable amount of power to set the flywheel cutter in motion, and as all modern machines are equipped with brakes, no time is lost in stopping. The load-leveling effect has increased feeds by an actual 10% in some instances at Lockheed.

—Eugene L. Strawn. *Western Machinery & Steel World*, Vol. 36, Feb. 1945, pp. 62-65.

## Spray Welding Pump Shafts

*Condensed from "Industry and Welding"*

Spray welding is proving of value to mine operators in southwestern Missouri since it solves maintenance problems simply and inexpensively. Due to the method of mining and the nature of the ore, the water in the mines contains a large percentage of sand in addition to other abrasives, corrosive materials, and chemicals.

Primary causes of wear on the pump shafts are fine corrosive particles that become embedded in the packing, and abrasive material in the water that runs in the bearings. In pumps not equipped with sleeves of hard metal or with adjustable shafts, worn shafts develop frequently.

After the shaft is removed from the pump, it is placed in a lathe to test for "true." If a dial indicator is not available, a colored pencil is used. Usually the shaft is set up in the lathe and turned back to true. Then the shaft and bearing are tested and the shaft polished. If it is bent, it is straightened by applying the necessary pressure with a short bar and block. Sometimes a small jack is used by placing it on the carriage of the lathe and applying pressure gradually.

When the shaft tests true, the shaft at the worn places is turned on the lathe several thousandths under size and a rough thread is cut through the places to be built up. This permits the applied metal to bond more easily.

The shaft is then thoroughly cleaned. Preheating is unnecessary, but the spray metal must be heated to just the right temperature. If too cold, it will not adhere properly and if too hot, its lasting qualities are partially destroyed. The shaft is built up sufficiently to make allowance for turning it back to the required size.

—Lee Brady. *Ind. & Welding*, Vol. 18, Feb. 1945, pp. 66-68.

New
**OAKITE**
**CrysCoat Process**
TRADE MARK REG. U. S. PAT. OFF.

**Assures**

**LONGER DIE LIFE**
**In Wire Drawing**

A new development now successfully used in many mills, the Oakite CrysCoat Process, produces a phosphate coating on ferrous rods and wire that makes possible significant advantages and economies in wire drawing.

**Improved Lubrication**

Rods or wire immersed in the recommended solution of Oakite CrysCoat No. 86 acquire a non-hygroscopic, ductile, crystalline coating of fine grain structure. This coating combines CHEMICALLY with the metal surface and thereby imparts a tenacious covering that not only acts as an ADDED lubricant but, in addition, it has the ability to adsorb and retain regular lubricants.

**Advantages Provided!**

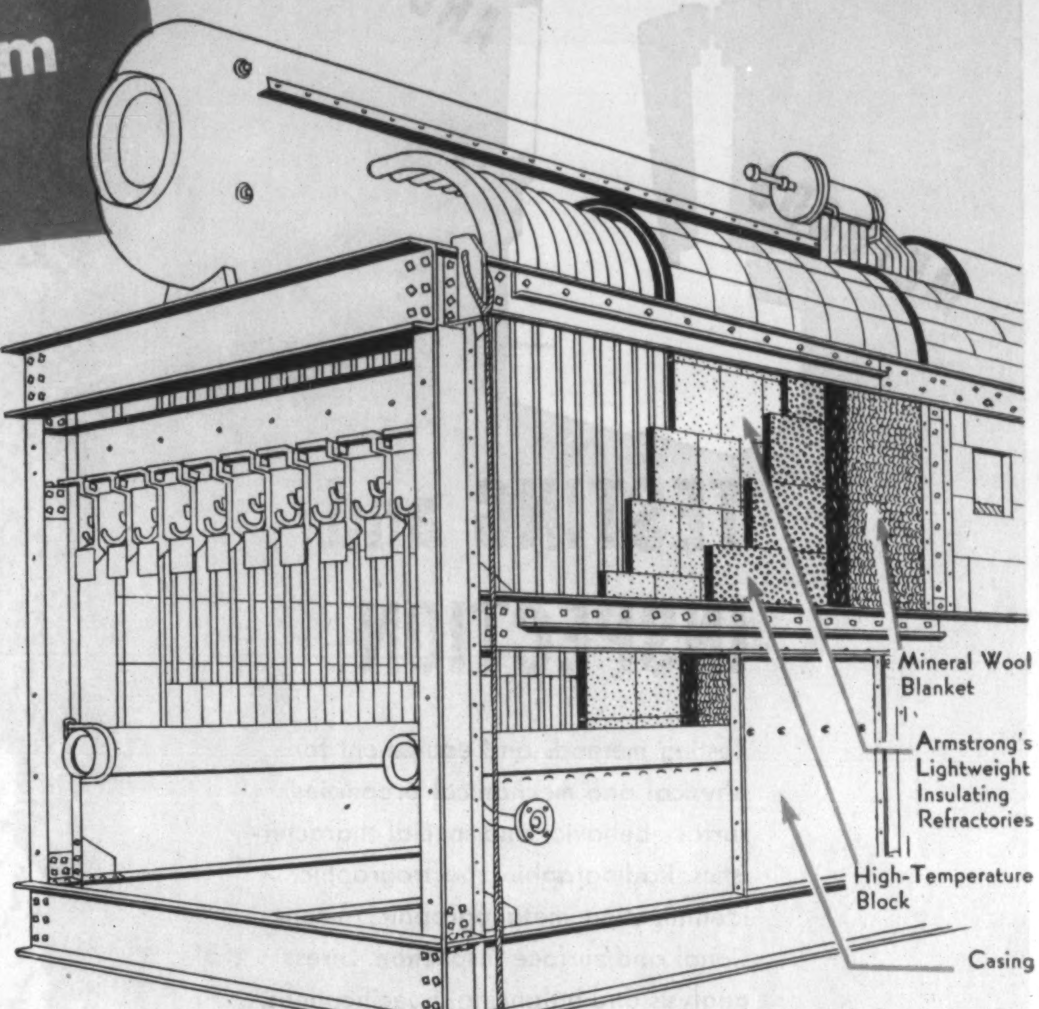
Among the PROVED advantages resulting from the use of Oakite CrysCoat No. 86 are increased production through less frequent changing or replacing of dies, longer die life, uniformly excellent wire appearance, shorter equipment downtime. Full details on this new Oakite technique may be had on request. Mill superintendents and other production executives are invited to send for their copy of a specially prepared service report. Write TODAY . . . there is no obligation.

**OAKITE PRODUCTS, INC.**
**32H Thames St., NEW YORK 6, N. Y.**
*Technical Service Representatives Located in All Principal Cities of the United States and Canada*

**OAKITE**
*Specialized cleaning*
Buy Bonds for Victory
MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

# Have you a boiler problem like this?

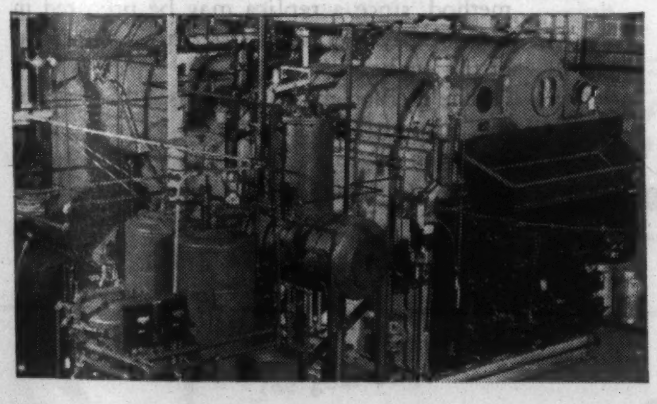
**To substantially reduce the weight of a boiler, without affecting its capacity or efficiency**



How Armstrong's Insulating Refractories were applied in the 80 boilers built for "packaged power" units shipped to Russia.

## Here's how it was solved . . . .

**TO BUILD** easily transportable, prefabricated electric-generating plants that could be set up quickly in the devastated cities of Russia presented a tough problem.



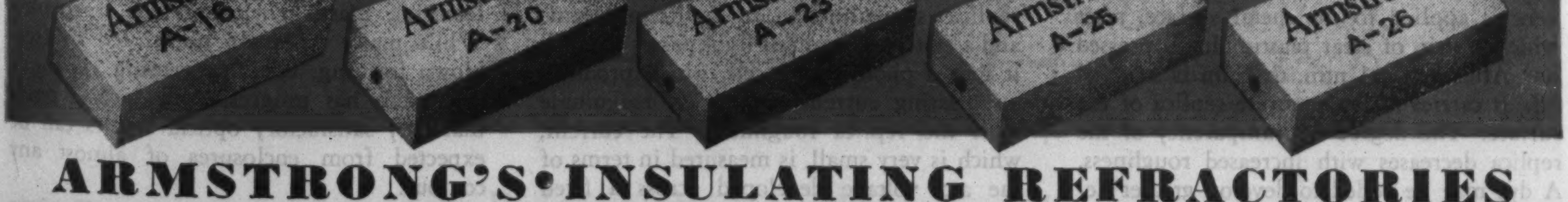
"Packaged power" unit set up for test at the Keeler plant.

Engineers of the E. Keeler Co. needed to make a large reduction in the tonnage of the boiler units in order to meet weight limitations. They were able to do this by using Armstrong's Insulating Fire Brick, instead of heavy refractory tile, behind the water tubes. Two thirds of the normal weight of the boiler lining were eliminated in this way. And these lighter refractories also provided extra insulation that contributed to more efficient boiler performance.

Because of the unusual strength and ruggedness of these lightweight tile, they were installed and delivered without trouble from crumbling or breakage.

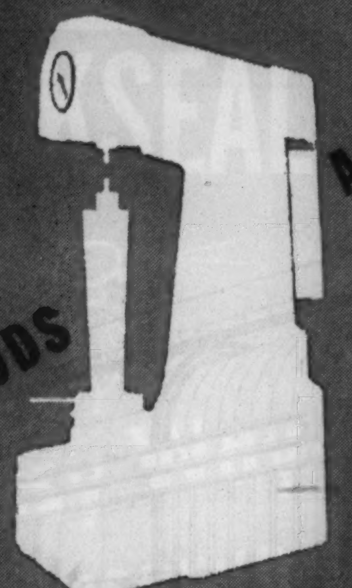
All five types of Armstrong's Insulating Fire Brick, for temperatures from 1600° to 2600° F., have high crushing strength, light weight, high insulating efficiency, low heat storage, high resistance to spalling, and great uniformity.

If you have a problem of reducing the weight or increasing the efficiency of a furnace or boiler, perhaps Armstrong's engineers can help you solve it. Write to Armstrong Cork Company, Insulating Refractories Department,
5505 Concord Street,
Lancaster, Pennsylvania.



**ARMSTRONG'S•INSULATING REFRACTORIES**

METHODS AND PROCESSES



# TESTING and INSPECTION

Testing methods and equipment for physical and mechanical properties, surface behavior and special characteristics. Radiographic, spectrographic, identification, metallographic, dimensional and surface inspection. Stress analysis and balancing. Specifications, standards and quality control.

## Replica Test for Metal Finish

*Condensed from "Journal of Research", National Bureau of Standards*

A method for evaluating surface finish by study of a replica offers promise. A solvent is applied to the metal surface, after which a strip of clear plastic film is pressed on. After about 1 min. the film is stripped off. It carries a very accurate replica of the surface. The degree of transparency of the replica decreases with increased roughness. A dye may be added to develop greater detail of the surface serrations.

The roughness of the replica is measured with an electrical-optical apparatus. The replica is mounted in an oscillating frame and a restricted beam of light passes through it into a photoelectric cell, which produces a pulsating current varying in magnitude with the replica roughness. The current, which is very small, is measured in terms of the a.c. voltage developed across a fixed resistor in series with the photocell.

The method was tested by comparing the results of the measurements of five specimens by this method with microscope measurements of the profiles of the specimens. Good correlation was found, with an almost straight line relationship between the voltage reading on the replica analyzer and root-mean-square profile values. The five specimens were, respectively, polished, lapped, fine-ground, fine-shapered, and coarse-shapered.

The replica method is especially sensitive to small changes in roughness in the range of the finer grades of finish. This is an advantage, since it is in this range that many conventional methods are not sufficiently sensitive.

The results reported are strictly applicable to surface markings, which are approximately unidirectional. Further work is planned to ascertain the effect of orientation of surface markings.

Some of the advantages of the replica method are: (1) easy maintenance of a permanent record of a surface finish, (2) rapid average evaluation of a considerable length and width of a surface at one setting, (3) simplicity of operation, (4) absence of personal factor, and (5) availability of the method, since a replica may be prepared in one locality and transported to the location of the analyzer.

The method may also be useful for reaching inaccessible surfaces or for evaluating corrosion pitting.

—**H. K. Herschman.** *J. Res., National Bur. Standards*, Vol. 34, Jan. 1945, pp. 25-31

## Optical Test Methods for Plastics

*Condensed from "Aviation"*

Great strides have been made in manufacturing plastic enclosures for warplanes. While many types are not suited to free-blown forming, vacuum forming via lubricated dies has progressed to such a point that very satisfactory optical results can be expected from enclosures of almost any contour.

Inspection requirements and specifications

**GUESSWORK**
*can* be right, but
**TESTING**
can't be *wrong!*

By the time samples from a melt get through the rigorous check-testing that PSF prescribes (in such equipment, for example, as the Izod impact strength tester above, and the Brinell and the most modern machining facilities. PSF works in ordinary or alloy steels, always to the goal of precision.

46 YEARS OF STEEL CASTING KNOWLEDGE
**Pittsburgh**
**STEEL FOUNDRY CORPORATION**
GLASSPORT, PA.
Sales Offices: NEW YORK • PHILADELPHIA • WASHINGTON AND CHICAGO

*From a recent advertisement of Pittsburgh Steel Foundry Corporation.*

LIKE hundreds of other manufacturers, Pittsburgh Steel Foundry Corporation knows that "one test is worth a thousand expert opinions." Quick, simplified and accurate, Riehle machines speed production by testing the physical properties of materials before manufacture, during processing and in the final product.

Write for descriptive literature and prices on RIEHLE Impact Testers . . . also RIEHLE Hydraulic Testing Machines, Vickers Hardness Machines, Brinell Hardness Testers, Measuring Instruments.

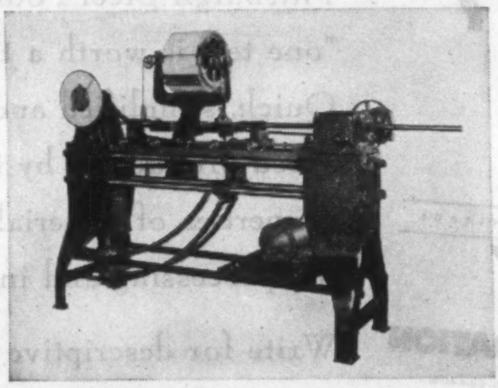
RIEHLE
UNIVERSAL
TESTING
MACHINES

Division of American Machine and Metals, Inc.
*EAST MOLINE, ILLINOIS*

TESTING *gives* CONTROL

An Adequate Testing Routine provides 4 essential controls:

**By being equipped with adequate physical testing apparatus, you accomplish: 1. Control of Research through world-standard test methods producing conclusive reference records. 2. Control of Purchasing, through scientific sampling. 3. Control of Manufacture, through a major-step testing routine to attain maximum production consistent with good quality. 4. Control of Acceptance-Inspection, through conclusive evidence of adherence to specifications. *Scott Testers are made in 60 models which furnish the wire industry with Standard apparatus for tensile, hysteresis, flexing, twist, compression-cutting (of rubber coating), etc., from finest filament wire to 1 ton.**



**Model Q-7 Scott Tester. Heavy duty tensile tester for wire with capacity of 2,000 lbs.**

***Request Circulars***

SCOTT TESTERS, INC.

**65 Blackstone St.** SCOTT TESTERS **Providence, R. I.**

***Registered Trademark**

*Scott Testers — Standard of the World*

should duplicate, as far as possible, the optical system and conditions under which the parts will operate. These applications are basically sighting or scanning.

For a test setup, two principal means are available. The most obvious makes use of a sight, usually a low-power rifle scope, taking a "bead" through the formed panel to a target. On a production basis, eye strain and fatigue develop, and more economical results may be obtained by projecting cross-lines on a target.

Using the projection method, the enclosure is mounted on a movable fixture so that the part may be swung, in relation to the light beam, through arcs of movement duplicating arcs traversed by sight mounted within the enclosure. In the darkened area an adjustable target is mounted in level position along a simulated line of sight.

As the enclosure moves, deflection of the light beam by surface irregularities causes cross lines to travel about the target, the amount being a direct measure of the error introduced by distortion. If the error exceeds the tolerance, the part is rejected.

If bore-sighting is used in the optical system, this may be incorporated into the inspection. The target and projected lines are coordinated, and the part is mounted on a fixture in any convenient position in relation to the line of sight.

Selection of an optical inspection method for scanning panels, which will operate in terms of definite standards, is far less straightforward than in the case of sighting panels. Purely visual methods are subject to variation in results. Where distortion is slight, it is almost impossible to obtain consistent results.

A better method is the use of a point source of light. In this method, a dark room is used and the enclosure is introduced between the light and screen or the white wall. The part is moved in such a way that the position of the light approximates the observer's head in the enclosure.

The lensing effect of irregularities tends to disperse light rays from the point of illumination, resulting in readily observable light and dark areas. Clarity and extent of patterns is a measure of the degree of optical distortion.

—Thomas Gladwin. *Aviation*, Vol. 44, Jan. 1945, pp. 147-148, 254, 256.

## The Acoustic Strain Gage

*Condensed from*
*"Journal of Scientific Instruments"*

This gage is for the measurement of surface strains produced both by static and dynamic loading. The apparatus consists of a test gage, reference gage, and a control set. The note from the vibrating wire in the test gage is matched against the note from a similar wire vibrating in the reference gage.

The method of measurement is very sensitive, and under normal conditions strains

# EW! A helpful chart for Radiographers

## KODAK FILMS FOR INDUSTRIAL RADIOGRAPHY

### FILM CHARACTERISTICS

**THE choice of a film for a particular job depends upon the relative emphasis placed upon definition, contrast, and exposure time, and the available kilovoltages or intensity of gamma radiation.**

| Film | Characteristics |
|---|---|
| KODAK INDUSTRIAL X-RAY FILM<br>**TYPE M**<br>(CODE NO. 5159) | EXTRA fine grain and high contrast. "Made to order" for critical inspection, higher voltages, and the radiography of light metals such as aluminum, magnesium, and their alloys. Gives highest obtainable quality at 1000 kilovolts. For use direct or with lead-foil screens. |
| KODAK INDUSTRIAL X-RAY FILM<br>**TYPE A**<br>(CODE NO. 5160) | FINE grain and high contrast. Designed for the radiography of light metals at lower voltages and for 1000-kilovolt radiography of heavier steel parts. Its grain is not quite as fine as that of Type M, but its higher speed makes it more widely usable. For use direct or with lead-foil screens. |
| KODAK INDUSTRIAL X-RAY FILM<br>**TYPE F**<br>(CODE NO. 5134) | HIGHEST available speed and high contrast when used with calcium tungstate screens. Useful for examination of steel, brass, etc., with machines of limited kilovoltage.<br>Lower contrast when used direct or with lead-foil screens. Records large range of thicknesses in relatively small density range. |
| KODAK INDUSTRIAL X-RAY FILM<br>**TYPE K**<br>(CODE NO. 5135) | HIGHEST available speed for gamma-ray work when used direct or with lead-foil screens.<br>In work with calcium tungstate screens, Type K has about 1/10 the speed of Type F, but has higher contrast and greater density range. |
| EASTMAN<br>**NO-SCREEN X-RAY FILM**<br>(CODE NO. 5133) | USEFUL where higher contrast than that of Type K is needed; and where somewhat lower speed can be tolerated in gamma-ray radiography. Its high contrast makes it especially suitable for gamma-ray exposures. For use direct or with lead-foil screens. |
| EASTMAN<br>**BLUE BRAND X-RAY FILM**<br>(CODE NO. 5121) | IN WORK with calcium tungstate screens, Blue Brand is slightly slower than Type F under industrial conditions.<br>When used direct or with lead-foil screens, Blue Brand is similar to Type F used under the same conditions. |

### RELATIVE SPEED AND CONTRAST

THE relative speeds and contrasts given below apply only to the use of the film in direct exposures or with lead-foil screens, as indicated.

The *Type F* and *Blue Brand* films are primarily intended for exposure with calcium tungstate intensifying screens; under such conditions, their speed and contrast are much higher than indicated below.

The values listed in column one below apply to x-ray diffraction work as well as to radiography.

### DEVELOPMENT

**with Kodak Liquid X-ray Developer or Kodalk X-ray Developer (powders)**

| | Aluminum and other light alloys No screens | Thin steel and brass Lead-foil screens | With million-volt x-rays Lead-foil screens | With gamma rays Lead-foil screens | Normal Development at 68°F. (20°C.) in minutes | For maximum speed and contrast at 68°F. (20°C.) in minutes |
|---|---|---|---|---|---|---|
| RELATIVE SPEED | 30 | 40 | 30 | 30 | 5 | 8 |
| CONTRAST | HIGH | HIGH | HIGH | HIGH | | |
| RELATIVE SPEED | 100 | 100 | 100 | 100 | 5 | 8 |
| CONTRAST | HIGH | HIGH | HIGH | HIGH | | |
| RELATIVE SPEED | 200 | 200 | 200 | 360 | 5 | 5 |
| CONTRAST | MEDIUM | MEDIUM | MEDIUM | MEDIUM | | |
| RELATIVE SPEED | 530 | 400 | 425 | 500 | 5 | 8 |
| CONTRAST | MEDIUM | MEDIUM | MEDIUM | MEDIUM | | |
| RELATIVE SPEED | 600 | 400 | 250 | 300 | 5 | 8 |
| CONTRAST | HIGH | HIGH | HIGH | HIGH | | |
| RELATIVE SPEED | 200 | 200 | 200 | 360 | 5 | 5 |
| CONTRAST | MEDIUM | MEDIUM | MEDIUM | MEDIUM | | |

### APPROXIMATE RADIOGRAPHIC EQUIVALENCE FACTORS

**ALUMINUM is taken as the standard metal at 50 Kv.P. and 100 Kv.P., and steel at the higher voltages. The thickness of another metal is multiplied by the corresponding factor to obtain the approximate equivalent thickness of the standard metal. The exposure applying to this thickness of the standard metal is used.**

***Example:*** **If 0.5 inch of copper is to be radiographed at 200 Kv.P., multiply 0.5 by the factor 1.4 to obtain 0.7, the equivalent thickness of steel. Therefore, 0.5 inch of copper can be given the exposure required for 0.7 inch of steel.**

**The bronzes may require somewhat different factors than copper or brass, depending on their composition.**

| Kilovolts | Aluminum | Magnesium | 24ST Alloy | Steel | 18-8 Stainless Steel | Copper | Zinc | Brass | Lead |
|---|---|---|---|---|---|---|---|---|---|
| 50 | 1.0 | .6 | 1.4 | | | | | | |
| 100 | 1.0 | .6 | 1.2 | 22 | | | | | |
| 150 | | | | 1.0 | 1.0 | 1.5 | 1.4 | 1.4 | 12 |
| 200 | | | | 1.0 | 1.0 | 1.4 | 1.3 | 1.3 | 12 |
| 1000 | | | | 1.0 | | | | 1.2 | 5 |
| Gamma rays | | | | 1.0 | | | | 1.1 | 2.3 |

**or larger size (18″ x 22″) in three colors write Eastman Kodak Company, X-Ray Division, Rochester 4, N. Y.**

P. R. Co. ANNOUNCES . . .

for Production Measurement of Shell Surfaces

PRCo announces its Type CP Roughness Meter for the roughness measurement of the surfaces of high-explosive shells. The Roughness Meter enables the control of the surface roughness of shells on a practical production basis in much the same manner as the Profilometer checks surface roughness of precision machine parts.

In appearance and operation, the Roughness Meter resembles the Profilometer in except that it enables the measurement of surface irregularities so widely spaced as to be beyond the range of the Profilometer, generally used on smoother surfaces. The Roughness Meter employs a hand-operated Tracer which traces the surface of the shell and gives a reading on the meter directly in terms of microinches of average roughness.

To withstand the heavy use of the equipment on shell inspection lines and the extremely coarse surface found on shells, the Tracer used with this unit is heavy and rugged and uses a blunter, stronger tracing point than that with the Profilometer. The Tracer can be used by hand to measure from the tip of the ogive to the boattail, the Tracer point being self-adjusting to changes of curvature of from 1½" OD to flat.

Because of the importance of surface roughness in the performance of shells and, therefore, in the efficiency and accuracy of our artillery, Physicists Research Company is making every effort to give prompt delivery for this equipment. If your plant is faced with the problem of controlling the surface roughness of high-explosive shells, we will be pleased to have our representative call and discuss the matter in more detail with you. Complete information on the Type CP Roughness Meter will be gladly supplied on request.

PHYSICISTS RESEARCH COMPANY
343 SOUTH MAIN STREET · ANN ARBOR, MICHIGAN

of the order of $1 \text{ x } 10^{-6}$ stain equivalent can be recorded. The test gage may be used in remote positions and controlled from a distance.

In the test gage, a thin steel wire is mounted between two knife edges, one of which is free to move longitudinally. The wire is maintained vibrating at its natural frequency by an electrical method, and any relative movement between the knife edges will be accompanied by a change in pitch of the note.

In the reference gage, the tension of the wire may be varied by a micrometer screwhead, and the gage is used as a standard of reference. Adjustment of the screwhead will cause the frequency of the reference wire to approach that of the wire in the test gage, when beats will be produced.

When strains produced by static loads are being measured, a reading is obtained by reducing the beat frequency to zero, while for constantly changing strains a record is taken of the change in the beat frequency.

With the special screened lead it is possible to operate the gage at a distance of over 450 ft.; any number of gages may be controlled from one amplifier. The gage and control set are simple to operate, the gage is easy to calibrate, and the calibration is linear over a useful range. The gage will measure strains on a large variety of surfaces, including friable materials; it is stable and not easily affected by external vibrations.

The electrical circuit consists of two identical parts, the output of each being mixed and fed to a pair of headphones. The steel wire passes through two concentrated magnetic fields, and around one polepiece of each field is fixed a small coil. One connection from each coil is joined to the frame of the jack, which is also common with the body of the gage. The other end of the coil is connected separately to the two spring contacts of the jack.

Connection between the gage and control set is made by special twin core cable, each core being screened separately. The screen is used as the common earthed lead. One coil of the gage is connected through the screened lead across the secondary winding of an 8:1 transformer, the primary of the transformer being in the anode lead of an output pentode valve, this coil being the exciter. The pick-up coil is connected across the primary of a 35:1 microphone transformer, the secondary winding of which is part of the grid circuit of the same pentode valve.

—R. S. Jarrett. *J. Scientific Instruments*, Vol. 22, Feb. 1945, pp. 29-34.

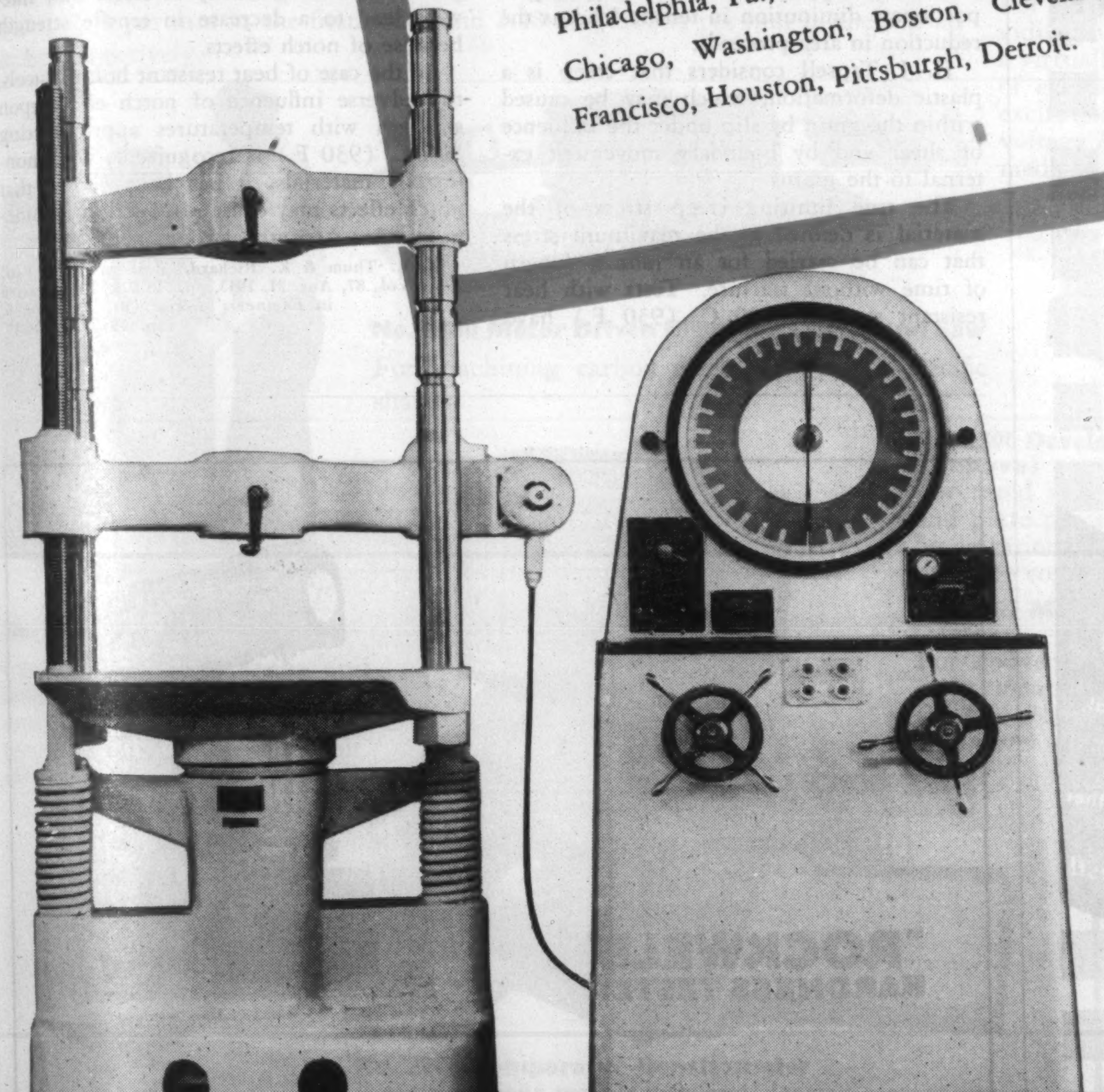
## Long-Period Stress Deformation

*Condensed from "The Engineers' Digest"*

The tensile strength and yield point of steels, metals and other materials are dependent upon the temperature at which they are tested. Strength properties are also variable with the length of subjection to load, and the yield point is dependent upon

# What's the designer's first consideration?

First essential is accurate knowledge of *physical properties*—and Baldwin testing equipment gives it on the spot. The Baldwin Locomotive Works, Baldwin Southwark Division, Philadelphia, Pa., U. S. A. Offices: Philadelphia, New York, Chicago, Washington, Boston, Cleveland, St. Louis, San Francisco, Houston, Pittsburgh, Detroit.



## ADVANTAGES

**EASE OF OPERATION:** Convenient grips . . . 66-inch multi-range dial . . . spot control crosshead adjustment . . . versatile valve controls.

**ACCURACY:** 99.8% over entire range, in a recent test of 100 machines.

**SENSITIVITY:** Read to ¼-lb. on a 100,000-lb. machine.

**CONTROL:** Controlled rate of loading, controlled head speed, and automatic load maintainer.

**RANGE CHANGE:** Ranges can be changed during test by turning knob.

**NULL METHOD:** Servo-motor Tate-Emery operated indicator, driving recorder and maximum hand without loss of accuracy; restores positive zero; gives true linear load scale.

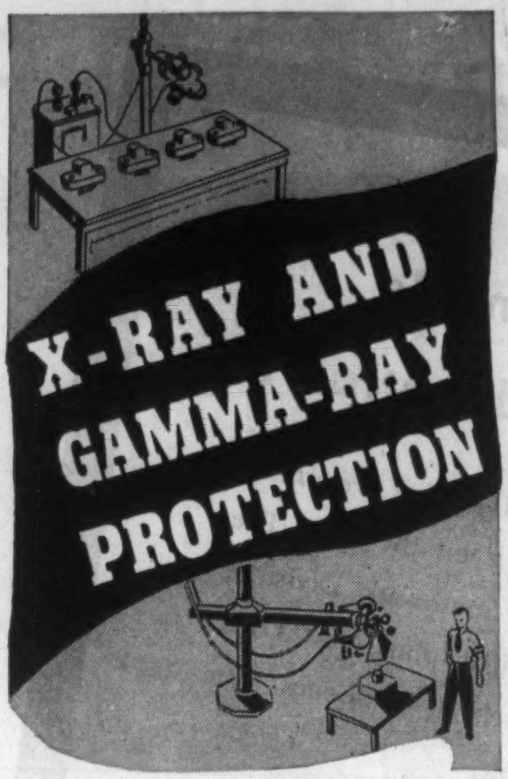
**CAPACITIES:** 60,000-lb. model illustrated. Others up to 5,000,000-lbs.

**OTHER BALDWIN PRODUCTS**

Hydraulic presses, Testing equipment, Steel forgings and castings, Diesel-electric locomotives, Diesel engines, Metal plate fabrication, Rolled steel rings, Bronze castings, Heavy machine work, Crane wheels, Bending rolls, Plate planers, Babbitt metal, Alloy iron castings, Briquetting presses, Sonntag fatigue machinery, SR-4 strain gages.

**BALDWIN**

**TESTING EQUIPMENT**



**YOU** may rely on us to solve all problems attendant upon the use of protective equipment . . . and to supply a material and method to meet U. S. Bureau of Standards requirements. Our engineers will submit plans and specifications on any problem of production, testing, or general protection of personnel. No obligation, of course!

**Among Those We Serve!**

Eclipse Aviation
Bethlehem Steel
Martin Bomber
DuPont Company
Bell Aircobra
Brooklyn Navy Yard
Fairchild Aviation
Wright Aeronautical
Sperry Gyroscope
Federal Shipyards
U. S. Army, Navy, Marine Corps and other Government agencies and war plants.

Other Installations on Request!

**WRITE FOR BAR-RAY CATALOG B5**

. . . contains description of materials, methods, installation procedure, diagrams, specifications, etc.

**BAR-RAY PRODUCTS, INC.**
**209—25th St., Brooklyn 32, N. Y.**

TEL: SOUTH 8-5225

AGENTS IN PRINCIPAL CITIES

the rapidity with which the tensile load is applied.

The time factor can generally be neglected, as the ultimate tensile strength obtained at room temperature and less generally differs but little from corresponding values of long-period strength. In steels, however, this factor comes into play when a temperature of 300 C. (570 F.) is reached.

In R. W. Bailey's opinion, the process of creep has three stages. In the first, strain hardening causes a gradual decrease in the rate of creep; in the second, opposing influences of strain hardening and loss of strength cause a constant rate; and in the third, loss of strength prevails and causes the creep rate to increase, finally leading to failure.

A contributing factor in the third stage is that specific stress increases due to the reduction of area caused by the progressive elongation of the material. Therefore, in the third stage creep acceleration can be practically suppressed by effecting a proportionate diminution in tensile load as the reduction in area proceeds.

H. J. Tapsell considers that creep is a plastic deformation, which may be caused within the grain by slip under the influence of shear and by boundary movement external to the grains.

The true limiting creep stress of the material is defined as the maximum stress that can be carried for an infinite length of time without fracture. Tests with heat resistant steels at 500 C. (930 F.) have shown that true limiting creep stress is not reached even with tests extending over several years. If this remains true over decades, the concept of so-called creep limit determined by standardized test procedure will need to be replaced by data established in consideration of required service life. For this, the time-strength relationship curve must be known and design dimensions must frequently be determined on the basis of time-to-fracture values.

The application of stresses exceeding the true limiting creep stress causes a gradually developing damage to the structure with consequent loss of strength. The damage line, representing the limit condition which characterizes incipient damage, can be obtained from fatigue tests.

With static tensile stress, the stress concentration caused by notch effect increases the strength of mild and medium hard steels. More brittle materials show a decrease in strength, and at low temperatures the diminished ductility of steels may likewise lead to a decrease in tensile strength because of notch effects.

In the case of heat resistant bolting steels, the adverse influence of notch effect upon strength with temperatures approximating 500 C. (930 F.) is recognized. With nonferrous materials, it has been shown that notch effects may cause a reduction in time-to-fracture strength at room temperature.

—A. Thum & K. Richard. *Zeitschrift des VDI*, Vol. 87, Aug. 21, 1943, pp. 513-520; as abstracted in *Engineers' Digest* (British), Vol. 6, Jan. 1945, pp. 16-19.

---

**"ROCKWELL" HARDNESS TESTER**

Do you ever stop to realize that while freezing and melting points are fixed points in pyrometry that there are no natural standards of hardness?

That is why our standardizing laboratory does and must control our product, and always has.

AN ASSOCIATE COMPANY OF AMERICAN CHAIN & CABLE COMPANY, INC

**WILSON**
MECHANICAL INSTRUMENT CO. INC.
365 Concord Ave. New York 54, N. Y.

## Everything for the Spectrographic Laboratory from ONE SOURCE

**No. 2060 Grating Spectrograph**

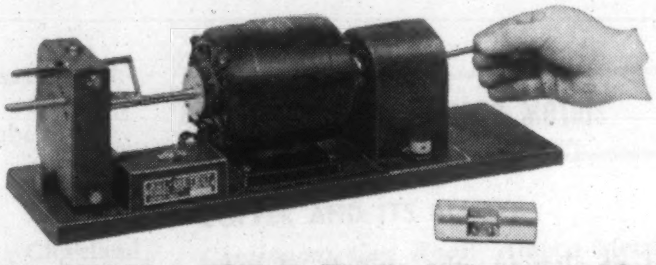
For unexcelled spectrum photography—available with either a 24,400 or a 36,600 line per inch original concave grating giving a linear dispersion of 6.95 and 4.64 A per mm in the first order and 3.48 and 2.32 A per mm in the second order respectively.

**No. 2050 Multisource Unit**

For exciting the spectra of samples and providing in one unit and in a superior manner, a virtually infinite variety of controlled types of excitation; ranging from the equivalent excitation of a high voltage spark, a high voltage A.C. arc or a D.C. arc and all intermediate cases.

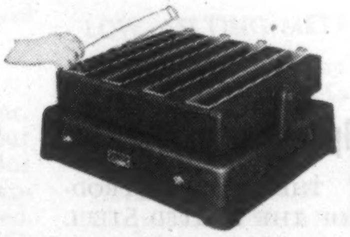
**No. 3500 Briquetting Press**

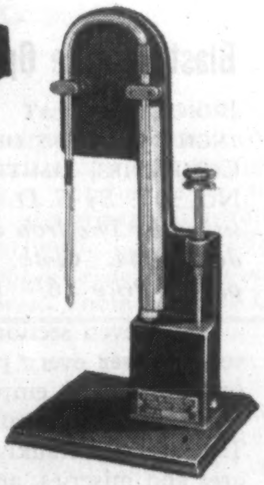
For briquetting borings and milled chips of metallic materials and powders of non-metallic materials into specimens suitable for spectrographic analysis.



**No. 2380 Motor Driven Electrode Cutter and Saw**

For machining carbon electrode tips to specific shapes.





**No. 2300 Developing Machine (*above*)**

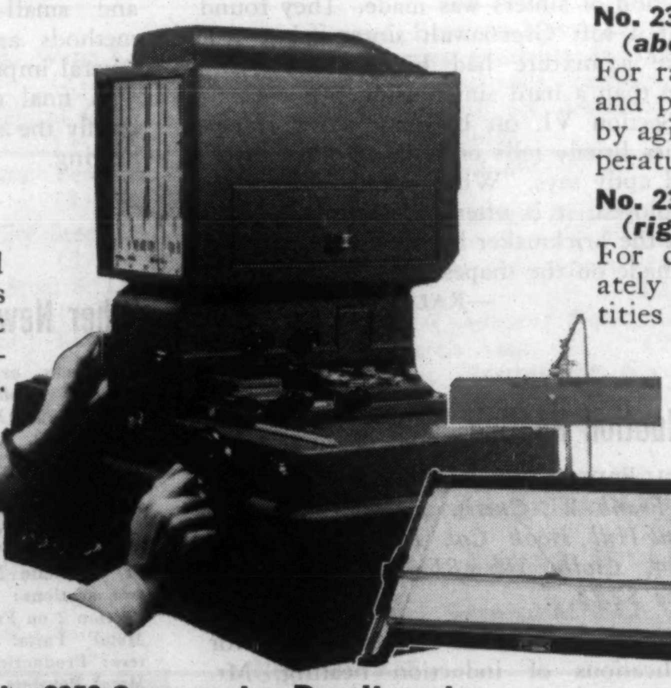
For rapid and consistent film and plate processing provided by agitation and accurate temperature control.

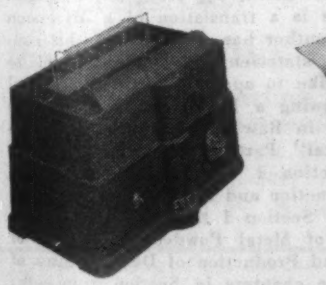
**No. 2397 Micro-Pipette (*right*)**

For conveniently and accurately measuring small quantities of solutions.

**The above spectrographic units** are but a few of the many pieces of "mated" equipment offered by ARL-DIETERT. These accessories work very well not only with ARL-DIETERT Spectrographs, but also with spectrographs of other makes and types.

Whether a motor generator set is needed, a spectrograph for precise analysis, or just a few feet of graphite electrodes, ARL-DIETERT is prepared to take care of your spectrographic needs or problems in an efficient and prompt manner.





**No. 2351 Plate Dryer**

For immediate drying of plates in from one to two minutes. Film Dryer also available.

**No. 2250 Comparator-Densitometer**

For convenient wavelength and density measurements—available for either film or plate spectrograms—wide range of master plates also available.

**No. 2375 Calculating Board (*right*)**

For the direct reading of sample composition from the transmission readings obtained from the Comparator-Densitometer.

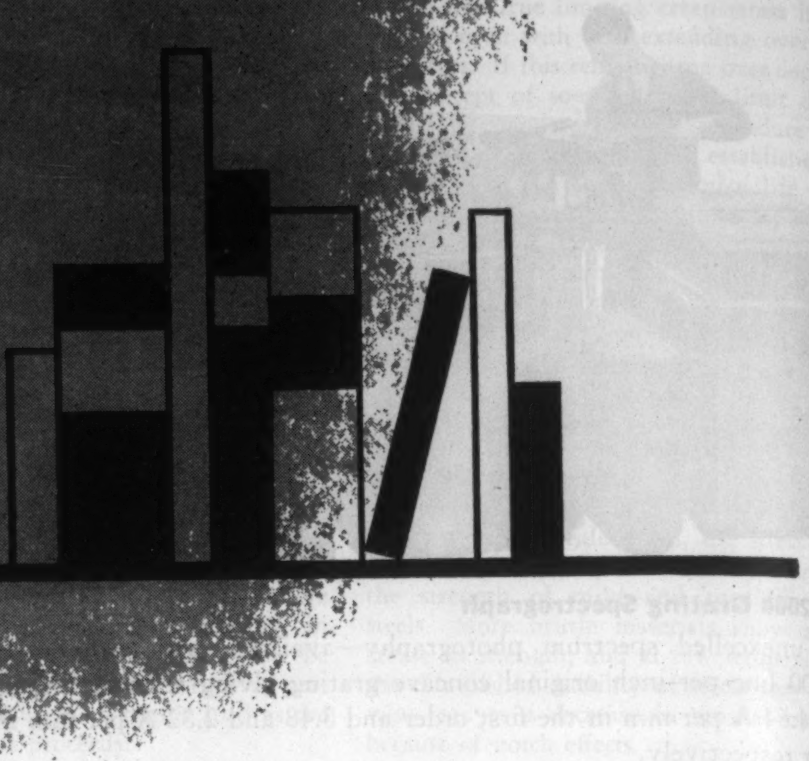
CONTROL SAVES TIME EQUIPMENT

# A.R.L. - DIETERT

APPLIED RESEARCH LABORATORIES
4336 SAN FERNANDO RD., GLENDALE 4, CALIF.

HARRY W. DIETERT CO.
9330 ROSELAWN AVE., DETROIT 4, MICH.

# engineering BOOKS



## Blast Furnace Operations

IRONMAKING AT THE APPLEBY-FRODINGHAM WORKS OF THE UNITED STEEL COMPANIES, LIMITED (SPECIAL REPORT NO. 30). *By G. D. Elliott and Staff. Published by The Iron & Steel Institute, London, 1944. Cloth 5½ x 8½ in., 280 pages. Price 16/- (Members, 10/-).*

The eleven sections of this voluminous report cover every phase of blast furnace operations, with emphasis on furnace troubles, especially scaffolds and breakouts. The authors frankly describe their failures and miseries, and say, "such troubles are still too frequent in British ironmaking, and until there is a much freer interchange of experience, are likely to remain too frequent." The authors also emphasize the need for more publications of a practical nature.

It is evident that they had suffered the pangs of a "lime bum" (which they call a "lime gob") for, on page 173 is the candid statement that: "Blast-furnace operation has suffered, and is still suffering, because no one man can live long enough to experience the full depths of depravity to which a furnace can sink."

Our American furnacemen in the Birmingham District, where they exchange Christmas greetings with the signature of "One scab maker to another," will appreciate the chapter on the removal of scabs and scaffolds.

Section II, on the blast-furnace burden, gives an excellent story of the transition from "man-size" (96 lb.) lumps of ore to the crushed, sized and bedded ore of the present day practice. Considerable detail of their Greenawalt and Dwight-Lloyd sintering plants, producing about 22,000 tons of sinter per week, is given, with some pungent remarks about the need of altering "the attitude of many technicians—that the sinter plant is the rubbish dump of an ironworks."

A very careful study of the rates of reduction of sinters was made. They found that a soft Greenawalt sinter using 5% coke admixture had higher reducibility rate than a hard sinter using 7% coke.

Section VI, on hot-blast stove refractories briefly tells of tests on stove brick, and aptly says, "When special shapes are employed, it is often worthwhile to consult the brickmaker before a final decision is made on the shapes to be used.

—RALPH H. SWEETSER

## Induction Heating

HIGH-FREQUENCY INDUCTION HEATING. *By Frank W. Curtis. Published by McGraw-Hill Book Co., Inc., New York, 1944. Cloth, 5½ x 8½ in., 235 pages. Price $2.75.*

Written to serve as a reference text for applications of induction heating, Mr. Curtis' book outlines standard practice for such work as heat-treating, brazing and soldering, forging, and melting. The subject-matter is limited to high-frequency heating, and rules out such large-scale applications as steel melting.

Fundamental principles of induction heating are outlined, and procedures that have been used successfully in industry are described in sufficient detail to serve as practice guides. A section of the book deals with design of parts for most effective heating by induction methods. Some interesting adaptations of standard induction heating fixtures to give high production are discussed.

As has been stated, the book is concerned with comparatively small parts. Especial emphasis has been placed upon heat treating applications and brazing and soldering techniques. Heating for forging and small-scale melting by induction methods are mentioned, however, with several important applications of each.

A final chapter in the book discusses briefly the similar techniques of dielectric heating.

—KENNETH ROSE

## Other New Books

PRINCIPLES OF POWDER METALLURGY. *By Frans Skaupy. Published by Philosophical Library, New York, N. Y., 1944. Cloth, 6¼ x 9¼ in., 80 pages. Price $3.00.* This is a translation of a discussion in German. The author has attempted in this contribution a short statement on the new field to which he would like to apply the name of "Metal Ceramics". Following a brief introduction, there is a General Part in Raw Products and Properties of "Ceramic Metal" Parts. This is followed by two sections: Section 1 on Metal Powders, and Section 2 on Production and Properties of "Ceramic Metal" Parts. In Section 1 there are three chapters: Production of Metal Powders, Properties of Metal Powders, and Production of Definite Sizes of Grains. The three chapters in Section 2 include: Production from Metal Powder Without Binding Agent, Production from Metal Powder by Employing a Binding Agent and Production of Alloys, and Properties of "Ceramic Metal" Bodies. There is also a special part containing two chapters on "Ceramics" of Wolfram, Molybdenum Tantalum and Other Metals, and on "Ceramics" of Hard Metals. The book concludes with an appendix.

WORKING PRINCIPLES OF ELECTRIC ARC WELDING. *Published by Welding Div., Harnischfeger Corp., Milwaukee 14, Wis., 1944. Paper, 5⅜ x 8⅜ in., 63 pages. Price $1.00.* P&H engineers, with the cooperation of the American Welding Society, other technical groups and some leading users of welding, compiled this book for welding operators and for design engineers concerned directly or indirectly with fabrication of metal products. A minimum of technical language and the series of exercises and instructions on various types of welds make the volume helpful for shop trainees.

# Manufacturers' Literature

## 1. Ferrous Metals

### ALLOY IRONS

*Ductile Alloy Iron.* Ferrous Metals Corp. (1-250)

*Molybdenum Cast Irons.* Molybdenum Corp. of America (1-136)

### ALLOY STEELS

*Machinery Steels.* Crucible Steel Co. of America. Handy data and stock information on a variety of Max-El machinery steels are presented in a 12-page, pocket-size folder. (1-297)

*Standard Steels.* Babcock & Wilcox Co. (1-197)

*Low Alloy Steel.* Bethlehem Steel Co. (1-117)

*Molybdenum in Steel.* Climax Molybdenum Co. (1-296)

*High Strength Steel.* Great Lakes Steel Corp. (1-2)

*High Strength Steel.* Inland Steel Co. (1-90)

*Special Steels.* A. R. Purdy Co., Inc. (1-194)

*National Emergency Steels.* Joseph T. Ryerson & Son, Inc. (1-204)

### CARBON STEELS

*Free-Cutting Bessemer Steels.* Bliss & Laughlin, Inc. (1-291)

*Steel.* Youngstown Sheet & Tube Co. (1-227)

### HIGH SPEED STEELS

*Mo-Max High Speed Steels.* Cleveland Twist Drill Co. (1-11)

*Tungsten-Molybdenum High Speed Steel.* Latrobe Electric Steel Co. (1-175)

### STAINLESS STEELS

*Stainless Steel.* Central Steel & Wire Co. (1-293)

*Stainless Steel.* Electro Metallurgical Co. (1-199)

*Stainless Steel Identification Data.* Peter A. Frasse & Co., Inc. (1-138)

*Stainless Clad Steel.* Granite City Steel Co. (1-256)

*Stainless Clad Steel.* Ingersoll Steel & Disc Div., Borg Warner Corp. (1-104)

*Fabrication of Stainless Steels.* Republic Steel Corp. (1-188)

*Heat Treatment of Stainless Steels.* Rustless Iron & Steel Corp. (1-279)

### TOOL AND DIE STEELS

*Die Steels.* Firth-Sterling Steel Co. Both HWD die steel for hot work and Cromovan die steel for cold work are discussed in a 4-page, illustrated folder. (1-298)

*Alloy Tool Steel.* H. Boker & Co., Inc. (1-237)

*Spark Testing Tool Steels.* Carpenter Steel Co. (1-230)

*Tool Steels.* Copperweld Steel Co. (1-228)

*Tool Steels.* Jessop Steel Co. (1-278)

*Tool and Special Steels.* Simonds Saw & Steel Co. (1-284)

### IRON AND STEELS—GENERAL

*Furnace-Treated Bar Steels.* La Salle Steel Co. Important factors in the selection of furnace-treated bar steels are presented in a 12-page illustrated bulletin, No. 5. Specifications are included. (1-299)

*Surface-Treated Sheet Steel.* American Rolling Mill Co. (1-286)

*Standard Steel Analysis Chart.* American Steel & Wire Co. (1-261)

## 2. Non-Ferrous Metals

### COPPER AND ITS ALLOYS

*Continuous Cast Rods.* Ampco Metal, Inc. Engineering Data Sheet No. 131, four pages, describes and illustrates continuous cast rods, made from several types of Ampcoloy bronzes. Specifications are included. (2-286)

*Bearing Bronze.* Bearium Metals Corp. The frictional properties available in Bearium Metal, and the bars, rods, castings, etc., made from this metal, are described in a 6-page, illustrated folder. (2-287)

*Copper Alloys in the Aircraft Industries.* American Brass Co. (2-158)

*Beryllium-Copper Castings.* Beryllium Corp. of Pennsylvania. (2-284)

*Engineering Bronzes.* Bridgeport Brass Co. (2-275)

*Bending Copper Tubes and Pipes.* Copper & Brass Research Assn. (2-241)

*Beryllium-Copper.* Instrument Specialties Co., Inc. (2-266)

*Phosphor Bronze.* Phosphor Bronze Smelting Co. (2-213)

*Weights and Data for Brass and Bronze Products.* Revere Copper & Brass, Inc. (2-170)

*Beryllium Copper.* Riverside Metal Co. (2-259)

*Phosphor Bronze.* Seymour Mfg. Co. (2-285)

### LIGHT METALS

*Magnesium Alloys.* American Magnesium Corp. (2-218)

*Aluminum Alloy Specifications.* American Smelting & Refining Co., Federated Metals Div. (2-253)

*Ingot Metal.* Bohn Aluminum Co., Michigan Smelting & Refining Div. (2-204)

*Magnesium Alloys.* Dow Chemical Co. (2-281)

*Aluminum Alloy.* National Bronze & Aluminum Foundry Co. (2-187)

***Please Use the Coupon on Page 1443***

*Aluminum—the Versatile Metal.* Reynolds Metals Co. (2-279)

### LOW-MELTING METALS

*Bismuth-Lead-Tin-Cadmium Alloy.* Cerro de Pasco Copper Corp. (2-189)

### SPECIAL METALS

*Hard Facing Metal.* Fansteel Metallurgical Corp. Fanweld, a hard facing metal containing no steel, requiring no heat treating, and that resists wear, abrasion, heat and impact, is described in a 4-page, illustrated folder. Prices are included. (2-288)

*"Foote-Prints"—a house organ on rare metals, alloys and ores.* Foote Mineral Co. (2-267)

*Metallic Hydrides.* Metal Hydrides, Inc. (2-144)

*Metal Powders.* Powder Metals & Alloys, Inc. (2-149)

*Hard Facing Alloys.* Wall-Colmonoy Corp. (2-251)

## 3. Engineering Design

### ALLOY CASTINGS

*Heat- and Corrosion-Resistant Castings.* Alloy Casting Co. (3-497)

*Manganese Steel for Oil Field Service.* American Manganese Steel Div., Am. Brake Shoe Co. (3-432)

*Heat Resisting Alloy.* Chicago Steel Foundry Co. (3-19)

*Alloy Castings.* Duraloy Co. (3-375)

*Nickel-Chromium Castings.* Electro Alloys Co. (3-326)

*Alloy Castings.* Sterling Alloys, Inc. (3-380)

### CASTINGS—IRON, STEEL, NON-FERROUS, ETC.

*Beryllium Copper Castings.* Akron Bronze & Aluminum Co. The properties and applications of several Viculoy beryllium copper castings that possess fatigue, conductivity and special properties are discussed in an 8-page bulletin. (3-556)

*Castings.* Meehanite Research Institute. A very interesting collection of articles about Meehanite castings, which have appeared in various trade publications, is presented in a 127-page bulletin, No. 22. (3-561)

*Heat Treated Aluminum Castings.* Acme Aluminum Alloys, Inc. (3-290)

*Special Castings.* Advance Foundry Co. (3-381)

*Castings, Forgings, Etc.* American Brake Shoe Co. (3-499)

*Steel Castings.* American Steel Castings Co. (3-530)

*Acid-Resisting Alloy.* Duriron Co., Inc. (3-191)

*Data on Brass and Bronze Castings.* Hammond Brass Works. (3-194)

*Non-Ferrous Castings.* Howard Foundry Co. (3-333)

*Carbon and Low Alloy Cast Steels.* Lebanon Steel Foundry. (3-498)

*Alloy Castings.* Michiana Products Corp. (3-512)

*Cast Steel Breech Rings.* Ohio Steel Foundry Co. (3-447)

*Rotary Blowers.* Roots-Connersville Blower Corp. (3-229)

*Centrifugal Castings.* Shenango-Penn Mold Co. (3-250)

*Magnesium Castings.* Superior Bearing Bronze Co., Inc. (3-532)

### DIE CASTINGS, PRECISION CASTINGS, ETC.

*Die Casting and Permanent Mold Casting.* American Metal Co., Ltd. (3-542)

*Castings.* Monarch Aluminum Mfg. Co. (3-527)

*Designing Die Castings.* New Jersey Zinc Co. (3-373)

*Die Castings.* New Products Corp. (3-468)

*Die Castings.* Pryor Mfg. Co. (3-551)

### FORGINGS

*Designing Impression Die Forgings.* Drop Forging Assn. (3-378)

*Steel Forgings.* Transue & Williams Steel Forging Co. (3-383)

### METAL PARTS

*Chain Belts.* Chain Belt Co. Chain belts made of Rex Z-Metal, a ductile ferrous cast metal with both high tensile strength and yield point, are described in a 4-page, illustrated, pocket-size folder, No. 460. (3-559)

*Coiled Springs.* Lee Spring Co., Inc. Physical factors and manufacturing considerations that affect the design of coiled springs wound with initial tension is the subject of a 4-page, illustrated reprint. (3-560)

*Screws, Studs, Bolts, Etc.* Aircraft Screw Products Co., Inc. (3-479)

*Ball and Roller Bearing Specifications.* Anti-Friction Bearing Manufacturers Assn. (3-548)

*Thermostatic Bi-Metal.* Callite Tungsten Corp. (3-427)

*Flexible Metal Hose.* Chicago Metal Hose Corp. (3-515)

*Solder-Backed Contacts.* Gibson Electric Co. (3-545)

*General Purpose Bearings.* Johnson Bronze Co. (3-245)

*Porous Bronze Bearings.* Keystone Carbon Co. (3-331)

*Pressure Vessel Fittings.* Lenape Hydraulic Pressing & Forging Co. (3-41)

*Wear Resistant Precious Metal Parts.* Permo, Inc. (3-65)

*Covers for Ball and Roller Bearings.* R-S Products Corp. (3-192)

*Step-Taper Tubes.* Summerill Tubing Co. (3-385)

*Bearings.* Timken Roller Bearing Co. (3-528)

*Wire Staples.* E. H. Titchener & Co. (3-525)

*Ball Reciprocating Bearings.* Torrington Co. (3-536)

*Steel, Bronze, Etc. Precision Balls.* Vulcanite Portland Cement Co. (3-547)

*Eyelets, Ferrules, Etc.* Waterbury Companies, Inc. (3-534)

*Magnet Steel Cores.* Westinghouse Electric & Mfg. Co. (3-329)

*Screw Products.* Wisconsin Screw Co. (3-546)

*Steel Stampings.* Worcester Pressed Steel Co. (3-555)

### NON-METALLICS

*Laminated Plastic.* Westinghouse Electric & Mfg. Co. This 2-page, illustrated advertisement describes Micarta, a laminated industrial plastic, for use in gears, aircraft parts, pump rings, insulation problems, etc. (3-562)

*Gaskets and Sealing Materials.* Armstrong Cork Co. (3-255)

*Plastic Laminate.* Continental Can Co. (3-475)

*Plastics.* Continental-Diamond Fibre Co. (3-467)

*Resistant Glass.* Corning Glass Works. (3-495)

*Plastics.* Dow Chemical Co., Plastics Div. (3-420)

*Plastics.* E. I. duPont de Nemours & Co., Inc., Electrochemicals Dept. (3-500)

*Plastics.* Durez Plastics & Chemicals, Inc. (3-235)

*Plastic Data Book.* Formica Insulation Co. (3-210)

*Plastics.* General Electric Co. (3-523)

*Industrial Rubber Products.* B. F. Goodrich Rubber Co. (3-540)

*Plastics, Resins, Etc.* Hercules Powder Co. (3-541)

*Plastic Custom Molding.* Imperial Molded Products Corp. (3-389)

*Molded Plastic Products.* Plastic Manufacturers, Inc. (3-430)

*Plywood Tubing.* Plymold Corp. (3-509)

*Plastics.* Richardson Co. (3-403)

*Cellular Rubber.* Sponge Rubber Products Co. (3-533)

### POWDER METALLURGY

*(See also Sec. 2—Special Metals; Sec. 3—Metal Parts; and Sec. 8—Metal Powder Processing)*

*Powder Metallurgy Parts.* Moraine Products Div., General Motors Corp. (3-139)

*Powder Metallurgy.* Powder Metallurgy Corp., Div. General Bronze Co. (3-441)

### TUBING

*Tubing, Etc.* Youngstown Welding & Engineering Co. Weldco corrosion-resisting tubing, formed welding fittings, and fabricated piping are all described and illustrated in an 8-page bulletin, No. T145. Specifications are included. (3-563)

*Boiler Tubes.* Bissett Steel Co. (3-553)

*Spun End Tubes.* Calumet & Hecla Consolidated Copper Co., Wolverine Tube Div. (3-322)

*Piping.* Flori Pipe Co. (3-345)

*Welded Steel Tubing.* Formed Steel Tube Institute. (3-223)

*Steel Analysis Chart.* Globe Steel Tubes Co. (3-485)

*History of Piping.* Tube Turns, Inc. (3-303)

### OTHER METAL FORMS

*Welded Steel Plate Construction.* Central Boiler & Mfg. Co. How foundries utilize a welded steel process in the construction of much of their equipment is discussed in a 4-page, illustrated bulletin. (3-557)

*Steel Fabrication.* Falstrom Co. Complete information on the facilities of this company for producing fabricated welded parts and assemblies, and numerous illustrations of the products manufactured, is presented in an 8-page bulletin. (3-558)

*Zinc-Plated Steel.* American Nickeloid Co. (3-330)

*Weldments.* Graver Tank & Mfg. Co., Inc. (3-425)

*Magnet Steels.* Indiana Steel Products Co. (3-340)

*Sheet Wire, Tubing, Etc.* D. E. Makepeace Co. (3-529)

*Spinning Equipment.* Milwaukee Metal Spinning Co. (3-315)

*Design-Strengthened Metal.* Rigid-Tex Corp. (3-552)

*Spring and Wire Forms.* Wickwire Spencer Steel Co. (3-517)

## 4. Melting • Refining • Casting

### ALLOYING AGENTS

*Aluminum Alloys.* National Smelting Co. (4-187)

*Titanium Alloys.* Titanium Alloy Mfg. Co. (4-128)

### AUXILIARIES

*Diecoats.* Foundry Services, Inc. This 2-page bulletin presents concise data on Foseco Dycoats for producing permanent mold castings of aluminum, magnesium, zinc, etc. (4-233)

*Electrode Unloader.* National Carbon Co., Inc. An economical and convenient device for unloading electrodes from box cars is described and illustrated in the fourth of a series of *Electrode Tips,* four pages. (4-234)

*Coatings and Refractory Parting Compound.* Refractory Mica Products, Inc. This 4-page bulletin discusses Micawash coatings for cores, sand molds, pots, etc., and Micaparte, a refractory parting compound for all metals. (4-235)

*Metallic Filler for Castings.* American Crucible Co. (4-176)

*Plaster Molding.* Castings Patent Corp. (4-219)

*Crucible Furnaces.* Crucible Manufacturers' Assn. (4-213)

*Magnetic Pulleys.* Dings Magnetic Separator Co. (4-169)

*Die Casting Machines.* Hydraulic Press Mfg. Co. (4-206)

*Casting Sealant.* Monsanto Chemical Co., Plastics Div. (4-231)

### MELTING FURNACES, MACHINES AND PARTS

*High Frequency Furnaces.* Ajax Electrothermic Corp. (4-60)

*Induction Furnaces for Aluminum Alloys.* Ajax Engineering Corp. (4-95)

*Melting Furnaces.* Campbell-Hausfeld Co. (4-79)

*Open-Hearth Furnace.* Day & Zimmermann, Inc. (4-230)

*Rocking Electric Furnace.* Detroit Electric Furnace Div., Kuhlman Electric Co. (4-188)

*Melting Furnace Accessories.* Fisher Furnace Co. (4-220)

*Recuperative Open Hearth Furnaces.* Fitch Recuperator Co. (4-101)

*Die Casting Machines.* Kux Machine Co. (4-228)

*Die Casting Machine.* Lester-Phoenix, Inc. (4-229)

*Regenerative Furnace Control.* Morgan Construction Co. (4-102)

*Electric Melting Furnaces.* Pittsburgh Lectromelt Furnace Corp. (4-61)

### RAW MATERIALS

*Bronze Casting Alloys.* American Manganese Bronze Co. The composition, characteristics and applications of many bronze casting alloys are presented in this 48-page catalog. (4-232)

*Ingot Metals.* Ajax Metal Co. (4-108)

## 5. Heating • Heat Treatment

### ATMOSPHERES AND GENERATORS

*Dry Cyaniding.* Surface Combustion Corp. Complete data on the dry cyaniding process in continuous furnaces are presented in a 4-page illustrated bulletin. (5-614)

*$SO_2$ in Magnesium Industry.* Ansul Chemical Co. (5-379)

*Anhydrous Ammonia.* Armour Ammonia Works. (5-435)

*Inert Gas.* Davison Chemical Corp. (5-588)

*Bright Annealing of Metals.* Lindberg Steel Treating Co. (5-576)

*Heat Treating with Ammonia.* Pennsylvania Salt Mfg. Co. (5-577)

*Drying Air or Gases.* Pittsburgh Lectrodryer Corp. (5-500)

### AUXILIARIES

*Oil Coolers and Heat Transfer Equipment.* Bell & Gossett Co. (5-476)

*Infra-Red Burners.* Burdett Mfg. Co. (5-427)

*Fans.* Despatch Oven Co. (5-412)

*Pressed Steel Pots.* Eclipse Fuel Engineering Co. (5-352)

*Cold Temperature Processing.* Kold-Hold Mfg. Co. (5-406)

*Cooling Coils.* Trane Co. (5-323)

### BATHS AND COMPOUNDS

*Heat Treating Baths and Furnaces.* A. F. Holden Co. A new Type 230 combination furnace is illustrated, and the melting points, operating ranges and uses of seven heat treating baths listed in a 4-page bulletin. (5-609)

*Salt Bath Quenching.* E. F. Houghton & Co. An interesting article on "interrupted" quenching in salt, including brief descriptions of Martempering and Austempering, is presented in a 12-page, illustrated bulletin. (5-610)

*Metal Treating.* American Cyanamid & Chemical Corp. (5-604)

*Quenching Oils.* Gulf Oil Corp. (5-455)

*Carburization Check.* Park Chemical Co. (5-351)

### BLOWERS AND COMPRESSORS

*Blower Catalog and Data Book.* Ilg Electric Ventilating Co. (5-228)

### BURNERS

*Luminous Flame Burner.* Bloom Engineering Co. A luminous Long-Flame burner for steel mill reheating furnace operations, designed to use gas and oil, is described and illustrated in an 8-page bulletin, No. 1001. (5-607)

*Oil Burners.* W. S. Rockwell Co. A variety of Industrial oil burners are described and illustrated in a 12-page bulletin, No. 416. Specifications and numerous diagrams are included. (5-613)

*Infra-Red Ray Burner.* Carbomatic Corp. (5-398)

*Oil and Gas Burners.* Peabody Engineering Corp. (5-597)

### ELECTRICAL HARDENING AND HEATING

*Electric Forging Heaters.* American Car & Foundry Co. (5-23)

### HIGH FREQUENCY HEATING

*Electronic Power Generator.* Radio Corp. of America, Electronic Apparatus Section. The RCA automatic electronic power generator, Model 2-B, is described and illustrated in a 4-page bulletin. Specifications are included. (5-612)

*Electronic Heaters.* Federal Electric Co., Inc. (5-593)

*High Frequency Generators.* Induction Heating Corp. (5-232)

*High Frequency Heating.* Lepel High Frequency Laboratories, Inc. (5-340)

*High Frequency Induction.* Ohio Crankshaft Co. (5-512)

*Electronic Heating.* Scientific Electric Div., "S" Corrugated Quenched Gap Co. (5-605)

### FURNACES

*Electric Pot Furnaces.* American Electric Furnace Co. (5-97)

*Furnaces and Furnace Equipment.* Amsler-Morton Co., Inc. (5-256)

*Blowerless Furnaces.* Baker & Co., Inc. (5-574)

*Furnace Periodical.* Chicago Flexible Shaft Co. (5-291)

*Bright Annealing Furnaces for Stainless Steel.* Drever Co. (5-224)

*Chain Belt Conveyor Furnaces.* Electric Furnace Co. (5-166)

*Heat Treating Furnaces.* Fabricated Steel & Engineering Co. (5-599)

*Electric Furnaces.* General Electric Co. (5-469)

*Rotary Forging Furnaces.* George J. Hagan Co. (5-265)

*Electric Furnace.* Harper Electric Furnace Corp. (5-579)

*Electric Furnaces.* C. I. Hayes, Inc. (5-499)

*Convection Tempering Furnace.* Hevi-Duty Electric Co. (5-538)

*Heat Treating and Laboratory Furnaces.* K. H. Huppert. (5-303)

*Tempering and Drawing Furnace.* Johnson Gas Appliance Co. (5-307)

*Heat-Treat Furnaces.* Lindberg Engineering Co. (5-414)

*Gas-Carburizing Furnace.* Lithium Corp. (5-586)

*Stress-Relief Furnace.* Mahr Mfg. Co. (5-487)

*Heat Treating Furnaces.* Salem Engineering Co. (5-341)

*Electric Furnace.* Sentry Co. (5-523)

> *In this Manufacturers' Literature INDEX, new bulletins are given complete reviews, and previously described older bulletins are merely listed in their proper places.*

*Electric Furnace.* Thermo Electric Mfg. Co. (5-590)

*Electric Salt Bath Furnaces.* Upton Electric Furnace Div., Commerce Pattern Foundry & Machine Co. (5-295)

*Induction Heating Units.* Van Norman Co. (5-396)

*Heat Treating Furnaces.* Vulcan Corp. (5-243)

### OVENS

*Foundry Ovens.* Gehnrich Oven Div., W. S. Rockwell Co. A complete line of foundry ovens for process drying, baking finishes and drying coatings is profusely illustrated in a 28-page catalog, No. 114. (5-608)

*Infra-Red Equipment.* Infra-Red Engineers & Designers. This 2-page bulletin describes and illustrates Miskella insulated-reflective ovens using Quality lamped or solid units, or combinations of both. Specifications are included. (5-611)

*Heavy-Duty Heaters.* B. F. Sturtevant Co. (5-535)

*Heating Equipment.* Harold E. Trent Co. (5-578)

### PROCESSES

*Heat Treating Pistol Parts.* Ajax Electric Co., Inc. Complete data on the application of Isothermal heat treating of pistol parts are presented in an 8-page, illustrated reprint. (5-606)

*Infra-Red Heating.* C. M. Hall Lamp Co. Infra-red radiant heating equipment for drying paints and finishes, in metal control, for plastics, etc., is discussed in a 28-page, pocket-size booklet. (5-615)

*High-Speed Direct Air-Gas Heat.* American Gas Assn. (5-589)

*Surface Hardening.* Chapman Valve Mfg. Co. (5-149)

*Sub-Zero Treatment for Tools.* Alfred Heller Heat Treating Co. (5-575)

*Wear Phenomena.* Nitralloy Corp. (5-541)

**Continued on Next Page**

## MAIL THIS COUPON FOR FREE LITERATURE

***Metals and Alloys*, 330 West 42nd St., New York, N.Y.**

**I should like a copy of each piece of Manufacturers' Literature listed**

***We request students to send their inquiries to the manufacturers***

NO. NO. NO. NO.
NO. NO. NO. NO.
NO. NO. NO. NO.
NO. NO. NO. NO.

NAME POSITION

FIRM

MAILING ADDRESS ☐ HOME ☐ BUSINESS

CITY STATE

**PLEASE PRINT**

5/45

## 6. Refractories • Insulation

*Linings for Ladles.* Ironton Fire Brick Co. Ironton Caro-Line, a monolithic lining for side blow converters, is described in a one-page, illustrated reprint. (6-184)

*Fused Silica and Quartz Products.* Amersil Co., Inc. (6-182)

*Refractory Insulating Concrete.* Atlas Lumnite Cement Co. (6-66)

*Plastic Refractory.* Basic Refractories, Inc. (6-151)

*Plastic Super-Cement.* Botfield Refractories Co. (6-94)

*Refractory Coating Material.* Brickseal Refractory Co. (6-67)

*Masonry Saw.* Clipper Mfg. Co. (6-82)

*Flux Resistant Refractory.* Corhart Refractories Co. (6-95)

*Steel Plant Cement.* Electro Refractories & Alloys Corp. (6-149)

*Light-Weight Refractory.* A. P. Green Firebrick Co. (6-181)

*Fire Clays.* Illinois Clay Products Co. (6-174)

*Bonding Mortar.* M. W. Kellogg Co. (6-177)

*Ramming Mixture.* Laclede-Christy Clay Products Co. (6-112)

*Protective Refractory Coating.* George R. Mowat Co. (6-148)

*Brick Linings.* Plibrico Jointless Firebrick Co. (6-124)

*Refractory Products.* Charles Taylor Sons Co. (6-77)

*Vitreous Silica Pipes, Fittings.* Thermal Syndicate, Ltd. (6-50)

## 7. Welding

### BRAZING AND SOLDERING

*Welding Alloys.* Eutectic Welding Alloys Co. Specific applications and uses of EutecRods and EutecTrodes—Castolin Eutectic low-temperature welding alloys—are discussed in a 4-page, illustrated bulletin. A helpful selector chart is included. (7-365)

*Silver Brazing Alloy.* Handy & Harman. The many advantages of brazing with Easy-Flo, a silver brazing alloy, are presented in *Low Temperature Brazing News*, No. 31, two pages. (7-366)

*Acetylene Generators.* Air Reduction Co. (7-349)

*Welding, Brazing Aluminum.* Aluminum Co. of America. (7-192)

*Silver Flux.* Scaife Co. (7-224)

*Double-Strength Soldering Flux.* Wolfe-Kote Co. (7-321)

### ELECTRIC ARC WELDING

*Welding Electrode Comparison Chart.* Allis-Chalmers Mfg. Co. Comparing equipment from 22 electrode manufacturers, this 8-page bulletin, No. B6344 A, is a useful and informative chart on stainless steel and hard surfacing electrodes, as well as the mild steel type. (7-364)

*Arc Welding.* Hobart Brothers Co. This 24-page, pocket-size booklet presents in detailed drawings the common faults found in designs for arc welding, and suggests correct procedures for each case. (7-367)

*Hard Surfacing Electrodes.* Rankin Mfg. Co. A number of recommended applications of Ranite smooth-flowing, hard-surfacing electrodes are listed in a one-page bulletin. (7-368)

*Tool Steel Electrodes.* Alloy Rods Co. (7-325)

*Electrodes.* American Agile Corp. (7-233)

*Stainless Steel Welding.* Arcos Corp. (7-103)

*Arc Welders, Cranes, Etc.* Harnischfeger Corp. (7-333)

*Arc Welding.* Lincoln Electric Co. (7-363)

*Stainless Electrodes.* McKay Co. (7-174)

*Electrode Chart.* Metal & Thermit Corp. (7-361)

*Arc Torch.* Mid-States Equipment Co. (7-251)

*Hard Facing.* Mir-O-Col Alloy Co. (7-359)

*Stud Welder.* Nelson Specialty Welding Equipment Corp. (7-331)

### GAS WELDING

*Oxyacetylene Pipeline Distributing Systems.* Victor Equipment Co. Complete data on oxyacetylene pipeline distributing systems, from the production of calcium carbide and acetylene gas to the equipment needed for these systems, are presented in an 84-page, illustrated catalog. (7-370)

### RESISTANCE WELDING

*Seam Welders.* Sciaky Brothers. This attractive, 20-page bulletin, No. 113-A, describes and illustrates the Series PMM. 1, 180-KVA seam and roll spot welding machines for mild steels, stainless steels and non-ferrous alloys. Specifications and numerous diagrams are included. (7-369)

*Welding Electrodes and Alloys.* P. R. Mallory & Co., Inc. (7-342)

*Battery Welding Machines.* Progressive Welder Co. (7-346)

### SUPPLIES

*Welding Positioner.* Cullen-Friestedt Co. (7-68)

*Arc Welding Accessories.* General Electric Co. (7-229)

*Welding Electrodes.* Page Steel & Wire Div., Am. Chain & Cable Co. (7-340)

*Welding Electrodes.* A. O. Smith Corp. (7-261)

*Fluxes for Welding, Brazing, Etc.* Superior Flux Co. (7-341)

*Welding Electrodes.* Welding Equipment Supply Co. (7-344)

## 8. Metal-Working

### FORMING

*Plastic Hammers.* Industrial Products Suppliers. Artus Red-Hed plastic hammers, with non-ferrous metal cores, for work on highly-polished surfaces, fine lapped finishes, sheet metal work, etc., are described and illustrated in a 2-page folder. Prices are included. (8-642)

*Hydraulic Stretch-Forming.* North American Aviation, Inc. This 4-page, illustrated reprint presents an interesting article on the hydraulic stretch-forming of aircraft parts. (8-647)

*Pipe Bending Machine.* American Pipe Bending Machine Co., Inc. (8-501)

*Hydraulic Presses.* Anderson Brothers Mfg. Co. (8-279)

*Hydraulic Presses.* Charles E. Francis Co. (8-471)

*Stretch-Forming Machine.* Hufford Machine Works, Inc. (8-636)

*Double-Flaring Tool.* Imperial Brass Mfg. Co. (8-348)

*Sheet Metal Facilities.* Kirk & Blum Mfg. Co. (8-333)

*Hydraulic Presses.* Lake Erie Engineering Corp. (8-248)

*Precision Bender.* Leonard Precision Products Co. (8-518)

*Hydraulic Pumps.* Lyon-Raymond Corp. (8-603)

*Steel Plate Fabrication.* Marine Fabricators Co. (8-599)

*Automatic Benders.* Pines Engineering Co., Inc. (8-586)

*Tangent Bender.* Struthers-Wells Corp. (8-592)

*Vertical Punches.* Thomas Machine Mfg. Co. (8-539)

*Ground Stock, Die Blocks, Etc.* Tool Craft Co. (8-609)

*Inclinable Open Back Presses.* V & O Press Co. (8-633)

*Hole-Punching Units.* Wales-Strippit Corp. (8-379)

*Punches and Dies.* Wiedemann Machine Co. (8-617)

### FORGING

*Hydraulic Presses.* A. B. Farquhar Co., Ltd. (8-146)

*Automatic Drop Hammers.* Standard Machinery Co. (8-404)

### MACHINING

*Grinding Wheels.* Abrasive Co., Div. Simonds Saw & Steel Co. Complete data on grinding wheels, including selection tables, work speed tables, etc., are presented in an illustrated, 120-page, pocket-size booklet. (8-636)

*Tool Holder Bits.* Allegheny Ludlum Steel Corp. Mill-treated, high-speed steel tool holder bits are described in a new bulletin, and a table of finishes and lengths included. (8-637)

*Liquid Cooler.* Chrysler Corp., Airtemp Div. The cooling of machine tools with an Airtemp packaged liquid cooler, assuring more uniform results, increased production, longer tool life, etc., is described in a 10-page, illustrated bulletin. Specifications are included. (8-639)

*File Cleaner.* Cincinnati Tool Co. Two types of file cleaner, with and without chip plows, for cleaning files of soft metal chips, are described and illustrated in a one-page bulletin. Prices are included. (8-645)

*Grinding Wheels and Shapes.* Cleveland Quarries Co., Sterling Grinding Wheel Div. A complete list of Stermount wheels and shapes, with detachable spindles, for grinding and polishing is presented in a 4-page, illustrated bulletin. Prices are included. (8-648)

*Gear Shaper Cutters.* Colonial Tool Co. A complete line of basic standard and special shaper cutters, as well as the making of gears by the shaping process, is presented in a 24-page bulletin. (8-641)

*Belt Tension Control Backstand.* Divine Brothers Co. The DBY dry belt tension control backstand, and the lathes on which this backstand is used, is described and illustrated in a 4-page bulletin. Specifications are included. (8-640)

*Grinding Mill.* International Ore Corp. This 4-page folder describes and illustrates the Eagle mill, which grinds crystalline graphite to as low as one to two microns. (8-643)

*Spindle Machine.* Kindt-Collins Co. Bulletin No. B-3, four pages, describes and illustrates the Master spindle machine for cutting and finishing soft metal and wood. Specifications are included. (8-644)

*Resinoid Wheels.* Larco Diamond Tool Co. A supplementary price list and specifications of resinoid bonded, diamond impregnated wheels, for insertion in this company's regular catalog, consists of 11 pages. (8-646)

*Boring Tools.* Tungsten Carbide Tool Co. A complete line of both "convertible" carbide tipped and solid carbide boring tools, each available in four sizes, are described and illustrated in bulletin No. 115. (8-649)

*Tool Shanks and Cutter Bodies.* American Brake Shoe Co., Brake Shoe & Castings Div. (8-361)

*Tools for Hardened Steel.* Black Drill Co. (8-191)

*Grinders.* Blanchard Machine Co. (8-615)

*Quick Analysis of Tapping Troubles.* Henry P. Boggis & Co. (8-541)

*Oil Filters.* Briggs Clarifier Co. (8-538)

*Coolant and Cutting Oil Strainers.* George Butler Co. (8-625)

*Steel Milling with Carbide-Tipped Cutters.* Carboloy Co., Inc. (8-422)

*Coated Abrasives.* Carborundum Co., Globar Div. (8-366)

*Sump Tank Cleaner and Filter.* W. R. Carnes Co. (8-528)

*Metal Cutting Lubrication.* Cities Service Oil Co. (8-225)

*Hydraulic Broaching Presses.* Colonial Broach Co. (8-571)

*Band Filing.* Continental Machines, Inc. (8-409)

*Oil Filters.* Cuno Engineering Corp. (8-108)

*Precision Tools.* Electrix Corp. (8-601)

*Cutting Tools.* General Aircraft Equipment, Inc., Tool Div. (8-244)

*Portable Coolant Systems.* Gray-Mills Co. (8-364)

*Taps and Tapping Problems.* Greenfield Tap & Die Corp. (8-627)

*Finishing Machines.* Hammond Machinery Builders. (8-296)

*Hydraulic Surface Grinders.* Hill Acme Co. (8-293)

*Diamond Bonded Wheels.* Industrial Abrasives, Inc. (8-380)

*Filters.* Johns-Manville Corp. (8-316)

*Machine Tools.* Jones & Lamson Machine Co. (8-614)

*Cemented Carbides.* Kennametal, Inc. (8-301)

*Breeches.* Lapointe Machine Tool Co. (8-317)

*Tool Grinders.* K. O. Lee Co. (8-525)

*Coolant Pumps.* Logansport Machine Co. (8-626)

*Gear Finishers.* Michigan Tool Co. (8-596)

*Grinding and Finishing.* Minnesota Mining & Mfg. Co. (8-583)

*Grinding Wheels.* Norton Co. (8-276)

*Manufacturing Service.* Oiljak Mfg. Co., Inc. (8-604)

*Electric Hand Tool.* Precise Products Co. (8-602)

*Metal Cutting Machine.* Racine Tool & Machine Co. (8-389)

*Precision Machine Tools.* Reed-Prentice Corp. (8-467)

*Shankless Drill.* Republic Drill & Tool Co. (8-569)

*Ground Thread Taps.* Sossner Tap & Tool Corp. (8-594)

*Grinding With Oil.* D. A. Stuart Oil Co., Ltd. (8-523)

*Precision Grinding Wheels.* Universal Wheel & Abrasive Corp. (8-377)

*Liquid Honing Process.* Vapor Blast Mfg. Co. (8-475)

*Prolonging Cemented Carbide Tools.* Vascoloy-Ramet Corp. (8-229)

*Internal Grooving Tool.* Waldes Koh-I-Noor, Inc. (8-634)

### ROLLING

*Solid Steel Shear Knives.* Heppenstall Co. (8-224)

### METAL POWDER PROCESSING

*Powdered Metal Press.* Watson-Stillman Co. Machine No. 9206, a 400-ton powdered metal press for producing accuracy and consistently uniform structure density, is described and illustrated in a single sheet. Specifications are included. (8-650)

*Presses for Metal Powder Products.* E. W. Bliss Co. (8-573)

*Conical Mills.* Hardinge Co. (8-144)

*Cone Blender.* Patterson Foundry & Machine Co. (8-493)

*Mixers, Agitators, Etc.* H. K. Porter Co., Inc. of Pittsburgh, Pa. (8-542)

### RIVETING AND FASTENING

*Locking System.* Bardwell & McAlister, Inc. The Rosan locking system for threaded inserts and studs in metals, plastics or wood is described in a 4-page, illustrated bulletin. (8-638)

*Lock Nuts.* Columbia Nut & Bolt Co., Inc. (8-567)

*Nails, Rivets and Screws.* John Hassall, Inc. (8-438)

## 9. Cleaning • Finishing

### CLEANING

*Blast Cleaning Equipment.* American Foundry Equipment Co. A complete line of Air-blast equipment, including tanks, suction guns, nozzles, etc., is presented in an illustrated bulletin. (9-522)

*Electrolytic Cleaner.* W. D. Mac Dermid Chemical Co. Ferrodex, an electrolytic degreaser and cleaner for the surfaces of ferrous metals and alloys, is described in a 4-page illustrated bulletin. (9-524)

*Industrial Electric Washers.* Modern Maid Co., Inc. Two types of electric-automatic washers for industrial parts are described and illustrated in a 2-page bulletin. Prices and specifications are included. (9-525)

*Blast Cleaning Equipment.* Pangborn Corp. This attractive, 24-page bulletin describes 21 unusual problems in blast cleaning, and profusely illustrates a variety of Rotoblast and Airblast cleaning equipment used to overcome these problems. (9-526)

*Cleaning Machines.* Alvey-Ferguson Co. (9-317)

*Dust Control.* American Air Filter Co., Inc. (9-408)

*Metal Descaling.* Bullard-Dunn Div., Bullard Co. (9-205)

*De-Burring Process.* De Burr Barrel Co., Inc. (9-499)

*Metal Core Brush.* Fuller Brush Co., Industrial Div. (9-463)

*Repairing Chipping Hammers.* Ingersoll-Rand Co. (9-434)

*Metal Cleaning in War Time.* Magnus Chemical Co. (9-146)

*Scale- and Rust-Removing Solution.* Oakite Products, Inc. (9-376)

*Cleaning Equipment.* Optimus Equipment Co. (9-517)

*Sodium Silicate.* Philadelphia Quartz Co. (9-291)

*Glass Tanks.* Pittsburgh Plate Glass Co. (9-515)

*Surface Peening.* W. W. Sly Mfg. Co. (9-422)

**Please Use the Coupon on Page 1443**

### CHEMICAL TREATMENTS

*Gas-Fired Hot Dip Tanks.* Aeroil Burner Co., Inc. (9-496)

*Oxide Coating on Metals.* Alrose Chemical Co. (9-167)

*Blackening for Metals.* Enthone Co. (9-259)

*Finish for Steel.* Heatbath Corp. (9-243)

### ELECTROPLATING

*Tarnish-Resisting Plate.* Special Chemicals Co. Spekwite, a tarnish-resisting white finish that plates directly over nickel, brass, copper, iron, steel, etc. is discussed in a 2-page bulletin. (9-528)

*Plating Equipment.* Belke Mfg. Co. (9-473)

*Selenium Rectifiers.* Federal Telephone & Radio Corp. (9-442)

*Zinc Stripper.* Mac Dermid, Inc. (9-512)

### NON-METALLIC AND ORGANIC COATINGS

*Insulating Varnish.* Dow Corning Corp. This 8-page bulletin discusses DC 993, a high temperature, moisture proof, Silicon varnish for the insulation of electrical equipment. Specifications are included. (9-523)

*Porcelain Enameling Process.* Porcelain Enamel Institute. Complete data on the design and fabrication of metal parts for porcelain enameling are presented in a 20-page, illustrated bulletin. (9-527)

*Metallic Paint.* Wilbur & Williams Co. Blaze-Pruf Silverlume, a metallic paint designed especially for hot metal surfaces, is described in a one-page, reprinted advertisement. (9-529)

*Copper Coatings.* American Chemical Paint Co. (9-379)

*Industrial Finish.* Ault & Wiborg Corp. (9-505)

*Resin Baking Coatings.* Bakelite Corp. (9-478)

*Spray Finishing Systems.* Binks Mfg. Co. (9-362)

*Near Infrared Process.* Fostoria Pressed Steel Corp. (9-444)

*Rust-Inhibiting Wax Coatings.* S. C. Johnson & Son, Inc. (9-234)

*Radium Paint.* Lustrolite Cleveland Corp. (9-519)

*Protective Coating.* Mitchell-Bradford Chemical Co. (9-450)

*Rust Preventive.* Nox-Rust Corp. (9-348)

*Protective Coatings.* Quigley Co., Inc. (9-495)

*Metal Coating.* Rheem Research Products, Inc. (9-475)

*Rust Arresters.* Smith Oil & Refining Co., Industrial Oils Div. (9-377)

*Spray Finish Machines.* Spray Engineering Co. (9-182)

*Pumps for Paints, Sealers, Etc.* Stewart-Warner Corp. (9-497)

*Zinc Corrosion-Resistant Coatings.* United Chromium, Inc. (9-386)

### PICKLING

*Corrosion Resistant Ceramics.* Atlas Mineral Products Co. (9-72)

*Plastic Chemical Equipment.* Havek Corp. (9-435)

*Chemicals in Metal Industry.* Monsanto Chemical Co., Merrimac Div. (9-193)

*Storage and Mixing Equipment.* U. S. Stoneware Co. (9-521)

### POLISHING

*Mounted Wheels and Sticks.* Carborundum Co., Refractory Div. (9-419)

*Cleaning and Buffing Metal Parts.* Puritan Mfg. Co. (9-507)

*Deburring and Finishing Metal Parts.* Sturgis Products Co. (9-487)

## 6. Refractories • Insulation

*Linings for Ladles.* Ironton Fire Brick Co. Ironton Caro-Line, a monolithic lining for side blow converters, is described in a one-page, illustrated reprint. (6-184)

*Fused Silica and Quartz Products.* Amersil Co., Inc. (6-182)

*Refractory Insulating Concrete.* Atlas Lumnite Cement Co. (6-66)

*Plastic Refractory.* Basic Refractories, Inc. (6-151)

*Plastic Super-Cement.* Botfield Refractories Co. (6-94)

*Refractory Coating Material.* Brickseal Refractory Co. (6-67)

*Masonry Saw.* Clipper Mfg. Co. (6-82)

*Flux Resistant Refractory.* Corhart Refractories Co. (6-95)

*Steel Plant Cement.* Electro Refractories & Alloys Corp. (6-149)

*Light-Weight Refractory.* A. P. Green Firebrick Co. (6-181)

*Fire Clays.* Illinois Clay Products Co. (6-174)

*Bonding Mortar.* M. W. Kellogg Co. (6-177)

*Ramming Mixture.* Laclede-Christy Clay Products Co. (6-112)

*Protective Refractory Coating.* George R. Mowat Co. (6-148)

*Brick Linings.* Plibrico Jointless Firebrick Co. (6-124)

*Refractory Products.* Charles Taylor Sons Co. (6-77)

*Vitreous Silica Pipes, Fittings.* Thermal Syndicate, Ltd. (6-50)

## 7. Welding

### BRAZING AND SOLDERING

*Welding Alloys.* Eutectic Welding Alloys Co. Specific applications and uses of EutecRods and EutecTrodes—Castolin Eutectic low-temperature welding alloys—are discussed in a 4-page, illustrated bulletin. A helpful selector chart is included. (7-365)

*Silver Brazing Alloy.* Handy & Harman. The many advantages of brazing with Easy-Flo, a silver brazing alloy, are presented in *Low Temperature Brazing News*, No. 31, two pages. (7-366)

*Acetylene Generators.* Air Reduction Co. (7-349)

*Welding, Brazing Aluminum.* Aluminum Co. of America. (7-192)

*Silver Flux.* Scaife Co. (7-224)

*Double-Strength Soldering Flux.* Wolfe-Kote Co. (7-321)

### ELECTRIC ARC WELDING

*Welding Electrode Comparison Chart.* Allis-Chalmers Mfg. Co. Comparing equipment from 22 electrode manufacturers, this 8-page bulletin, No. B6344 A, is a useful and informative chart on stainless steel and hard surfacing electrodes, as well as the mild steel type. (7-364)

*Arc Welding.* Hobart Brothers Co. This 24-page, pocket-size booklet presents in detailed drawings the common faults found in designs for arc welding, and suggests correct procedures for each case. (7-367)

*Hard Surfacing Electrodes.* Rankin Mfg. Co. A number of recommended applications of Ranite smooth-flowing, hard-surfacing electrodes are listed in a one-page bulletin. (7-368)

*Tool Steel Electrodes.* Alloy Rods Co. (7-325)

*Electrodes.* American Agile Corp. (7-233)

*Stainless Steel Welding.* Arcos Corp. (7-103)

*Arc Welders, Cranes, Etc.* Harnischfeger Corp. (7-333)

*Arc Welding.* Lincoln Electric Co. (7-363)

*Stainless Electrodes.* McKay Co. (7-174)

*Electrode Chart.* Metal & Thermit Corp. (7-361)

*Arc Torch.* Mid-States Equipment Co. (7-251)

*Hard Facing.* Mir-O-Col Alloy Co. (7-359)

*Stud Welder.* Nelson Specialty Welding Equipment Corp. (7-331)

### GAS WELDING

*Oxyacetylene Pipeline Distributing Systems.* Victor Equipment Co. Complete data on oxyacetylene pipeline distributing systems, from the production of calcium carbide and acetylene gas to the equipment needed for these systems, are presented in an 84-page, illustrated catalog. (7-370)

### RESISTANCE WELDING

*Seam Welders.* Sciaky Brothers. This attractive, 20-page bulletin, No. 113-A, describes and illustrates the Series PMM. 1, 180-KVA seam and roll spot welding machines for mild steels, stainless steels and non-ferrous alloys. Specifications and numerous diagrams are included. (7-369)

*Welding Electrodes and Alloys.* P. R. Mallory & Co., Inc. (7-342)

*Battery Welding Machines.* Progressive Welder Co. (7-346)

### SUPPLIES

*Welding Positioner.* Cullen-Friestedt Co. (7-68)

*Arc Welding Accessories.* General Electric Co. (7-229)

*Welding Electrodes.* Page Steel & Wire Div., Am. Chain & Cable Co. (7-340)

*Welding Electrodes.* A. O. Smith Corp. (7-261)

*Fluxes for Welding, Brazing, Etc.* Superior Flux Co. (7-341)

*Welding Electrodes.* Welding Equipment Supply Co. (7-344)

## 8. Metal-Working

### FORMING

*Plastic Hammers.* Industrial Products Suppliers. Artus Red-Hed plastic hammers, with non-ferrous metal cores, for work on highly-polished surfaces, fine lapped finishes, sheet metal work, etc., are described and illustrated in a 2-page folder. Prices are included. (8-642)

*Hydraulic Stretch-Forming.* North American Aviation, Inc. This 4-page, illustrated reprint presents an interesting article on the hydraulic stretch-forming of aircraft parts. (8-647)

*Pipe Bending Machine.* American Pipe Bending Machine Co., Inc. (8-501)

*Hydraulic Presses.* Anderson Brothers Mfg. Co. (8-279)

*Hydraulic Presses.* Charles E. Francis Co. (8-471)

*Stretch-Forming Machine.* Hufford Machine Works, Inc. (8-636)

*Double-Flaring Tool.* Imperial Brass Mfg. Co. (8-348)

*Sheet Metal Facilities.* Kirk & Blum Mfg. Co. (8-333)

*Hydraulic Presses.* Lake Erie Engineering Corp. (8-248)

*Precision Bender.* Leonard Precision Products Co. (8-518)

*Hydraulic Pumps.* Lyon-Raymond Corp. (8-603)

*Steel Plate Fabrication.* Marine Fabricators Co. (8-599)

*Automatic Benders.* Pines Engineering Co., Inc. (8-586)

*Tangent Bender.* Struthers-Wells Corp. (8-592)

*Vertical Punches.* Thomas Machine Mfg. Co. (8-539)

*Ground Stock, Die Blocks, Etc.* Tool Craft Co. (8-609)

*Inclinable Open Back Presses.* V & O Press Co. (8-633)

*Hole-Punching Units.* Wales-Strippit Corp. (8-379)

*Punches and Dies.* Wiedemann Machine Co. (8-617)

### FORGING

*Hydraulic Presses.* A. B. Farquhar Co., Ltd. (8-146)

*Automatic Drop Hammers.* Standard Machinery Co. (8-404)

### MACHINING

*Grinding Wheels.* Abrasive Co., Div. Simonds Saw & Steel Co. Complete data on grinding wheels, including selection tables, work speed tables, etc., are presented in an illustrated, 120-page, pocket-size booklet. (8-636)

*Tool Holder Bits.* Allegheny Ludlum Steel Corp. Mill-treated, high-speed steel tool holder bits are described in a new bulletin, and a table of finishes and lengths included. (8-637)

*Liquid Cooler.* Chrysler Corp., Airtemp Div. The cooling of machine tools with an Airtemp packaged liquid cooler, assuring more uniform results, increased production, longer tool life, etc., is described in a 10-page, illustrated bulletin. Specifications are included. (8-639)

*File Cleaner.* Cincinnati Tool Co. Two types of file cleaner, with and without chip plows, for cleaning files of soft metal chips, are described and illustrated in a one-page bulletin. Prices are included. (8-645)

*Grinding Wheels and Shapes.* Cleveland Quarries Co., Sterling Grinding Wheel Div. A complete list of Stermount wheels and shapes, with detachable spindles, for grinding and polishing is presented in a 4-page, illustrated bulletin. Prices are included. (8-648)

*Gear Shaper Cutters.* Colonial Tool Co. A complete line of basic standard and special shaper cutters, as well as the making of gears by the shaping process, is presented in a 24-page bulletin. (8-641)

*Belt Tension Control Backstand.* Divine Brothers Co. The DBY dry belt tension control backstand, and the lathes on which this backstand is used, is described and illustrated in a 4-page bulletin. Specifications are included. (8-640)

*Grinding Mill.* International Ore Corp. This 4-page folder describes and illustrates the Eagle mill, which grinds crystalline graphite to as low as one to two microns. (8-643)

*Spindle Machine.* Kindt-Collins Co. Bulletin No. B-3, four pages, describes and illustrates the Master spindle machine for cutting and finishing soft metal and wood. Specifications are included. (8-644)

*Resinoid Wheels.* Larco Diamond Tool Co. A supplementary price list and specifications of resinoid bonded, diamond impregnated wheels, for insertion in this company's regular catalog, consists of 11 pages. (8-646)

*Boring Tools.* Tungsten Carbide Tool Co. A complete line of both "convertible" carbide tipped and solid carbide boring tools, each available in four sizes, are described and illustrated in bulletin No. 115. (8-649)

*Tool Shanks and Cutter Bodies.* American Brake Shoe Co., Brake Shoe & Castings Div. (8-361)

*Tools for Hardened Steel.* Black Drill Co. (8-191)

*Grinders.* Blanchard Machine Co. (8-615)

*Quick Analysis of Tapping Troubles.* Henry P. Boggis & Co. (8-541)

*Oil Filters.* Briggs Clarifier Co. (8-538)

*Coolant and Cutting Oil Strainers.* George Butler Co. (8-625)

*Steel Milling with Carbide-Tipped Cutters.* Carboloy Co., Inc. (8-422)

*Coated Abrasives.* Carborundum Co., Globar Div. (8-366)

*Sump Tank Cleaner and Filter.* W. R. Carnes Co. (8-528)

*Metal Cutting Lubrication.* Cities Service Oil Co. (8-225)

*Hydraulic Broaching Presses.* Colonial Broach Co. (8-571)

*Band Filing.* Continental Machines, Inc. (8-409)

*Oil Filters.* Cuno Engineering Corp. (8-108)

*Precision Tools.* Electrix Corp. (8-601)

*Cutting Tools.* General Aircraft Equipment, Inc., Tool Div. (8-244)

*Portable Coolant Systems.* Gray-Mills Co. (8-364)

*Taps and Tapping Problems.* Greenfield Tap & Die Corp. (8-627)

*Finishing Machines.* Hammond Machinery Builders. (8-296)

*Hydraulic Surface Grinders.* Hill Acme Co. (8-293)

*Diamond Bonded Wheels.* Industrial Abrasives, Inc. (8-380)

*Filters.* Johns-Manville Corp. (8-316)

*Machine Tools.* Jones & Lamson Machine Co. (8-614)

*Cemented Carbides.* Kennametal, Inc. (8-301)

*Breeches.* Lapointe Machine Tool Co. (8-317)

*Tool Grinders.* K. O. Lee Co. (8-525)

*Coolant Pumps.* Logansport Machine Co. (8-626)

*Gear Finishers.* Michigan Tool Co. (8-596)

*Grinding and Finishing.* Minnesota Mining & Mfg. Co. (8-583)

*Grinding Wheels.* Norton Co. (8-276)

*Manufacturing Service.* Oiljak Mfg. Co., Inc. (8-604)

*Electric Hand Tool.* Precise Products Co. (8-602)

*Metal Cutting Machine.* Racine Tool & Machine Co. (8-389)

*Precision Machine Tools.* Reed-Prentice Corp. (8-467)

*Shankless Drill.* Republic Drill & Tool Co. (8-569)

*Ground Thread Taps.* Sossner Tap & Tool Corp. (8-594)

*Grinding With Oil.* D. A. Stuart Oil Co., Ltd. (8-523)

*Precision Grinding Wheels.* Universal Wheel & Abrasive Corp. (8-377)

*Liquid Honing Process.* Vapor Blast Mfg. Co. (8-475)

*Prolonging Cemented Carbide Tools.* Vascoloy-Ramet Corp. (8-229)

*Internal Grooving Tool.* Waldes Koh-I-Noor, Inc. (8-634)

### ROLLING

*Solid Steel Shear Knives.* Heppenstall Co. (8-224)

### METAL POWDER PROCESSING

*Powdered Metal Press.* Watson-Stillman Co. Machine No. 9206, a 400-ton powdered metal press for producing accuracy and consistently uniform structure density, is described and illustrated in a single sheet. Specifications are included. (8-650)

*Presses for Metal Powder Products.* E. W. Bliss Co. (8-573)

*Conical Mills.* Hardinge Co. (8-144)

*Cone Blender.* Patterson Foundry & Machine Co. (8-493)

*Mixers, Agitators, Etc.* H. K. Porter Co., Inc. of Pittsburgh, Pa. (8-542)

### RIVETING AND FASTENING

*Locking System.* Bardwell & McAlister, Inc. The Rosan locking system for threaded inserts and studs in metals, plastics or wood is described in a 4-page, illustrated bulletin. (8-638)

*Lock Nuts.* Columbia Nut & Bolt Co., Inc. (8-567)

*Nails, Rivets and Screws.* John Hassall, Inc. (8-438)

## 9. Cleaning • Finishing

### CLEANING

*Blast Cleaning Equipment.* American Foundry Equipment Co. A complete line of Air-blast equipment, including tanks, suction guns, nozzles, etc., is presented in an illustrated bulletin. (9-522)

*Electrolytic Cleaner.* W. D. Mac Dermid Chemical Co. Ferrodex, an electrolytic degreaser and cleaner for the surfaces of ferrous metals and alloys, is described in a 4-page illustrated bulletin. (9-524)

*Industrial Electric Washers.* Modern Maid Co., Inc. Two types of electric-automatic washers for industrial parts are described and illustrated in a 2-page bulletin. Prices and specifications are included. (9-525)

*Blast Cleaning Equipment.* Pangborn Corp. This attractive, 24-page bulletin describes 21 unusual problems in blast cleaning, and profusely illustrates a variety of Rotoblast and Airblast cleaning equipment used to overcome these problems. (9-526)

*Cleaning Machines.* Alvey-Ferguson Co. (9-317)

*Dust Control.* American Air Filter Co., Inc. (9-408)

*Metal Descaling.* Bullard-Dun Div., Bullard Co. (9-205)

*De-Burring Process.* De Burr Barrel Co., Inc. (9-499)

*Metal Core Brush.* Fuller Brush Co., Industrial Div. (9-463)

*Repairing Chipping Hammers.* Ingersoll-Rand Co. (9-434)

*Metal Cleaning in War Time.* Magnus Chemical Co. (9-146)

*Scale- and Rust-Removing Solution.* Oakite Products, Inc. (9-376)

*Cleaning Equipment.* Optimus Equipment Co. (9-517)

*Sodium Silicate.* Philadelphia Quartz Co. (9-291)

*Glass Tanks.* Pittsburgh Plate Glass Co. (9-515)

*Surface Peening.* W. W. Sly Mfg. Co. (9-422)

**Please Use the Coupon on Page 1443**

### CHEMICAL TREATMENTS

*Gas-Fired Hot Dip Tanks.* Aeroil Burner Co., Inc. (9-496)

*Oxide Coating on Metals.* Alrose Chemical Co. (9-167)

*Blackening for Metals.* Enthone Co. (9-259)

*Finish for Steel.* Heatbath Corp. (9-243)

### ELECTROPLATING

*Tarnish-Resisting Plate.* Special Chemicals Co. Spekwite, a tarnish-resisting white finish that plates directly over nickel, brass, copper, iron, steel, etc. is discussed in a 2-page bulletin. (9-528)

*Plating Equipment.* Belke Mfg. Co. (9-473)

*Selenium Rectifiers.* Federal Telephone & Radio Corp. (9-442)

*Zinc Stripper.* Mac Dermid, Inc. (9-512)

### NON-METALLIC AND ORGANIC COATINGS

*Insulating Varnish.* Dow Corning Corp. This 8-page bulletin discusses DC 993, a high temperature, moisture proof, Silicon varnish for the insulation of electrical equipment. Specifications are included. (9-523)

*Porcelain Enameling Process.* Porcelain Enamel Institute. Complete data on the design and fabrication of metal parts for porcelain enameling are presented in a 20-page, illustrated bulletin. (9-527)

*Metallic Paint.* Wilbur & Williams Co. Blaze-Pruf Silverlume, a metallic paint designed especially for hot metal surfaces, is described in a one-page, reprinted advertisement. (9-529)

*Copper Coatings.* American Chemical Paint Co. (9-379)

*Industrial Finish.* Ault & Wiborg Corp. (9-505)

*Resin Baking Coatings.* Bakelite Corp. (9-478)

*Spray Finishing Systems.* Binks Mfg. Co. (9-362)

*Near Infrared Process.* Fostoria Pressed Steel Corp. (9-444)

*Rust-Inhibiting Wax Coatings.* S. C. Johnson & Son, Inc. (9-234)

*Radium Paint.* Lustrolite Cleveland Corp. (9-519)

*Protective Coating.* Mitchell-Bradford Chemical Co. (9-450)

*Rust Preventive.* Nox-Rust Corp. (9-348)

*Protective Coatings.* Quigley Co., Inc. (9-495)

*Metal Coating.* Rheem Research Products, Inc. (9-475)

*Rust Arresters.* Smith Oil & Refining Co., Industrial Oils Div. (9-377)

*Spray Finish Machines.* Spray Engineering Co. (9-182)

*Pumps for Paints, Sealers, Etc.* Stewart-Warner Corp. (9-497)

*Zinc Corrosion-Resistant Coatings.* United Chromium, Inc. (9-386)

### PICKLING

*Corrosion Resistant Ceramics.* Atlas Mineral Products Co. (9-72)

*Plastic Chemical Equipment.* Havek Corp. (9-435)

*Chemicals in Metal Industry.* Monsanto Chemical Co., Merrimac Div. (9-193)

*Storage and Mixing Equipment.* U. S. Stoneware Co. (9-521)

### POLISHING

*Mounted Wheels and Sticks.* Carborundum Co., Refractory Div. (9-419)

*Cleaning and Buffing Metal Parts.* Puritan Mfg. Co. (9-507)

*Deburring and Finishing Metal Parts.* Sturgis Products Co. (9-487)

## 10. Testing • Quality Control

### CONTROL INSTRUMENTS

*Electronic Resistance Thermometers.* Bailey Meter Co. Bulletin No. 230-A, 12 pages, describes and illustrates Pyrotron electronic resistance thermometers in indicating, recording and controlling models. (10-633)

*Remote Mechanical Control.* M. L. Bayard & Co. Complete data on standard related units of a remote mechanical control system are presented in an 8-page, illustrated bulletin, No. A-100. Specifications and numerous diagrams are included. (10-637)

*Industrial Electronics Training Set.* General Electric Co. A complete set of training material on industrial electronics is profusely illustrated and described in a 4-page bulletin, No. GES-3303. Price is included. (10-635)

*Cathode Ray Tubes.* North American Philips Co., Inc. Complete data on cathode ray tubes, including early history, manufacturing problems, testing, etc., are presented in four reprints incorporated into a 16-page, illustrated bulletin. (10-636)

*Electric Timers.* C. H. Stoelting Co., Industrial Div. A variety of electric timers, including precision chronoscopes, spring-wound X-ray timers, stop clocks, etc., are described and illustrated in a 4-page bulletin, No. 1100. (10-639)

*Temperature Controllers.* American Gas Furnace Co. (10-475)

*Air Operated Controller.* Askania Regulator Co. (10-587)

*Valve Operators.* Automatic Temperature Control Co. (10-450)

*Direct-Reading Dilatometer.* Bristol Co. (10-514)

*Hot Blast Control.* Brown Instrument Co. (10-421)

*Temperature Control.* Burling Instrument Co. (10-620)

*Flow Rate Indicator.* Fischer & Porter Co. (10-624)

*Pressure Recorder Catalog.* Foxboro Co. (10-250)

*Pyrometers.* Illinois Testing Laboratories, Inc. (10-483)

*Electric Control.* Leeds & Northrup Co. (10-612)

*Control Instruments and Conservation.* Manning, Maxwell & Moore, Inc. (10-257)

*Shielded Pressure Tubes.* Revere Co. (10-590)

*Thermocouples, Etc.* Wheelco Instruments Co. (10-609)

### HARDNESS TESTING

*Hardness Tester.* B. C. Ames Co. (10-535)

*Hardness Tester for Soft Metals.* Barber-Colman Co. (10-218)

*Equipment for Hardness Testing.* Clark Instrument, Inc. (10-229)

*Hardness Testers.* Wilson Mechanical Instrument Co. (10-599)

### INSPECTION DEVICES

*Scanning Recorder.* Baldwin Locomotive Works, Baldwin-Southwark Div. This 4-page bulletin describes and illustrates the SR-4 scanning recorder, used in the static testing of structures for the rapid recording of 48 parallel SR-4 bridges. (10-642)

*Micrometer-Comparator.* Federal Products Corp. The new Model 120 B-1 micrometer-comparator with three-wire thread attachments, for production inspection and miscellaneous tool room use, is described and illustrated in a 4-page bulletin. Specifications are included. (10-634)

*Plug Gage Blanks.* George Scherr Co., Inc. The new Atlantic Emergency Set of 36 cylindrical plug gage blanks is one of the feature items of *Precise Production,* No. 108, four pages. Illustrations and prices are included. (10-638)

*Wear Resistance Tester.* Taber Instrument Co. This 4-page folder profusely illustrates and describes the Taber Abraser for testing the wear resistance of practically all types of surface finishes. Prices are included. (10-640)

*Electronic Supplies.* Walker-Jimieson, Inc. This new edition of available stock, including tubes, rectifiers, X-ray machines, demagnetizers, etc., consists of 48 pages. Prices and numerous illustrations are included. (10-641)

*Thread Gages.* Cadillac Gage Co. (10-595)

*Identification of Steel.* Dravo Corp. (10-271)

*Electronic Metal Identifier.* Allen B. DuMont Laboratories, Inc. (10-479)

*Optical Contour Comparator.* Fish-Schurman Corp. (10-628)

*Optical Testing Equipment.* Gamma Instrument Co. (10-621)

*Magnaflux Inspection.* Magnaflux Corp. (10-248)

*Balancing Machines.* Tinius Olsen Testing Machine Co. (10-429)

*Measuring Surface Roughness.* Physicists Research Co. (10-616)

*Illuminated Magnifiers.* E. W. Pike & Co. (10-345)

*Precision Gages.* Standard Gage Co., Inc. (10-631)

### MECHANICAL TESTING

*Stress-Strain Recording.* Baldwin-Southwark Div. (10-318)

*Mechanical Testing.* Riehle Testing Machine Div., Am. Machine & Metals, Inc. (10-455)

### METALLOGRAPHIC EQUIPMENT

*Optical Instruments.* Bausch & Lomb Optical Co. (10-357)

*Metallurgical Laboratory Equipment.* Buehler, Ltd. (10-199)

*Metallurgical Polishing Equipment.* Precision Scientific Co. (10-174)

### RADIOGRAPHY

*X-Ray Films.* Ansco. (10-315)

*X-Ray and Radium Protection.* Bar-Ray Products. (10-626)

*Industrial X-Ray Units.* General Electric X-Ray Corp. (10-324)

*X-Ray Cassettes.* Picker X-Ray Corp. (10-486)

### SPECTROGRAPHY

*Universal Spectrophotometers.* Wilkens-Anderson Co. (10-180)

### LABORATORY AIDS

*Gas Analysis Apparatus.* Burrell Technical Supply Co. (10-584)

*Laboratory Equipment.* Central Scientific Co. (10-507)

*Moisture Tellers.* Harry W. Dietert Co. (10-411)

*High-Speed Electrolytic Analysis.* E. H. Sargent & Co. (10-219)

*Please Use the Coupon on Page 1443*

## 11. Equipment and Machinery, General

*Vibration Control.* Korfund Co., Inc. Bulletin No. CF-1, four pages, describes and illustrates the installation of a Diesel engine in a building not designed for it, without any resulting vibration transmission. (11-336)

*Settling and Dewatering Equipment.* Claude B. Schneible Co. Bulletin No. 1144, four pages, describes and illustrates a complete line of settling and dewatering equipment for disposing of sludge from wet method dust collectors, etc. Specifications are included. (11-337)

*Mill Floor Cleaner.* G. H. Tennant Co. A complete scientific system of cleaning mill floors, including the restoring, hardening and burnishing of the floor surfaces, is described in a 4-page, illustrated bulletin. (11-368)

*Filters.* U. S. Hoffman Machinery Corp. An attractive, 54-page loose-leaf folder describes and illustrates a complete line of industrial filters for every production requirement. Specifications are included. (11-339)

*Transmissions.* Western Manufacturing Co. Three types of transmissions for motorizing various cone-driven machine tools are described and profusely illustrated in a 6-page folder. (11-340)

*Colloidal Graphite Dispersions.* Acheson Colloids Corp. (11-330)

*Junior Pug Mill.* Wm. M. Bailey Co. (11-278)

*Production Research.* Battelle Memorial Inst. (11-296)

*Continuous Printer.* Charles Bruning Co., Inc. (11-290)

*Mounted Wheels for Portable Tools.* Chicago Wheel & Mfg. Co. (11-70)

*Protective-Type Motor.* Crocker-Wheeler Div., Joshua Hendy Iron Works. (11-320)

*Linograph Transfer Paper.* Eastman Kodak Co. (11-293)

*Refrigeration and Air Conditioning Equipment.* General Electric Co. (11-243)

*Electric Arc Etchers.* George Gorton Machine Co. (11-305)

*Oil Filters.* Hilliard Corp. (11-292)

*Hydraulic Equipment.* Hydraulic Machinery, Inc. (11-201)

*Autoclaves.* Industrial Machinery Co. (11-332)

*Corrosion Data.* International Nickel Co., Inc. (11-97)

*Impregnating Castings.* Jackson & Church Co. (11-222)

*Centrifugal Pumps.* Marlow Pumps. (11-333)

*Sub-Zero Refrigeration.* Motor Products Corp., Deep-Freeze Div. (11-142)

*Steam Condenser.* Niagara Blower Co. (11-328)

*Dust Preventives.* Parsons Engineering Corp. (11-233)

*Water Softeners.* Permutit Co. (11-75)

*Air Processing Equipment.* Peters-Dalton, Inc. (11-218)

*Lubrication for Steam Turbines.* Sinclair Refining Co., Inc. (11-197)

*Vacuum Cleaners.* Spencer Turbine Co. (11-98)

*High Vacuum Pumps.* F. J. Stokes Machine Co. (11-152)

*Air Conditioning Equipment.* Westinghouse Electric Elevator Co., Air Conditioning Div. (11-289)

*Dust Suppressor.* Whiting Corp. (11-200)

# engineering NEWS

## of the metal-working industries

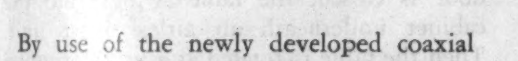
These rather surprising developments are highly interesting as showing the broad extent to which these mate rials are being used in the war effort It would be a satisfaction to know in just what applications the vari ous types are used but some of this is robably a military secret It would gratifying if the d ta on these

## Harnessing of Induction Generators

By use of the newly developed coaxial equalizer, *Induction Heating Corp.*, 389 Lafayette St., New York 3, is now able to couple two of their standard model 1070 thermonic induction generators so that the full output of both can be obtained from a single set of terminals.

Since each generator has an output of 1070 b.t.u.'s per min., full 40 kw. of power is available for use in any desired application with a single control station operating the tandem generator set-up.

The installation of the coaxial equalizer (made up of concentric tubular conductors) requires only the connection of the equalizer to the output terminals of the generators. An additional interconnection is made between the power sections of the generators to give electrical stability. The equipment can be operated single-phase, two-phase or three-phase, making it possible to install the equipment from any power supply with the full load power factor at approximately 90%.



The generators can be operated separately, each having an output of 20 kw. or less, at the same time permitting larger work to be accomplished when necessary. Since surface hardening requires a minimum of 5 kw. per sq. in. of surface to be hardened, the addition of the second model 1070 operated in conjunction with an original installation greatly increases the scope of work that can be handled.

The model 2200 thermonic set-up, illustrated, having an output of 40 kw., can surface harden 8 or more sq. in. of material in a single heating cycle. Its production output can be greatly increased by using progressive heating methods where small sections are heated and the work progressively moved through the heating coil.

## Electronic Induction Heater

A new electronic induction heater for brazing, soldering, annealing, hardening and pre-forge heating applications is announced by the *Allis-Chalmers Mfg. Co.*, Milwaukee.

With a low-loss coupling arrangement, the electronic generator can be adapted to a wide variety of metal-working applications without the use of radio-frequency transformers. Predetermined automatic timing controls each unit operation, assuring uniform production quality. The operator pushes the start button, and when the operation is completed, the unit automatically shuts off.

Other features include a current limiting circuit for protecting the oscillator filament and prolonging tube life; a three-phase rectifier on larger size units to obtain maximum power and prevent unbalance of the power line; safety devices for full protection of operator and unit. All models having a capacity of 10 or more kilowatts operate from either 220 or 440 volts, three-phase supply.

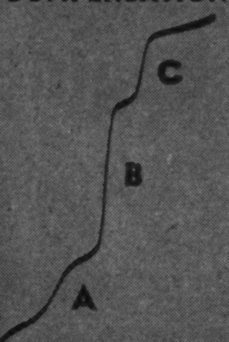
● A new non-ferrous alloy that can be supplied in the form of drop forgings or open frame hammer forgings is called "Wyndaloy Chace 720 forgings," and made by the *Wyndale Mfg. Corp.*, 1203 Cornell Ave., Indianapolis. It is available in the as-forged condition, or as-forged and heat treated, or as-forged, machined and heat treated. It is non-magnetic, has high strength, wear resistance, electrical resistivity and good corrosion resistance. Heat treatments will produce forgings with a hardness of 400 to 500 Brinell, tensile of over 200,000 p.s.i., and yield point of over 150,000 p.s.i. It is silvery in color and will take a high polish.

THE NEW MODEL XII

**Heyrovsky Polarograph**

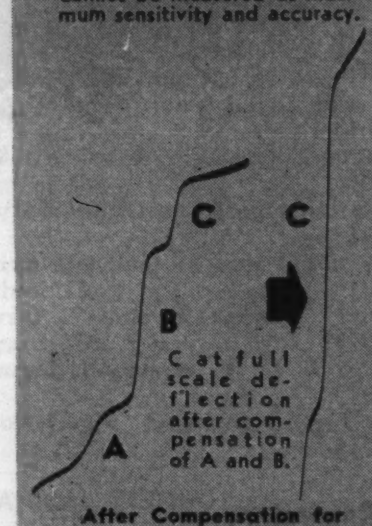
incorporates counter current compensation and improved camera.

USE OF COUNTER CURRENT COMPENSATION



**Before Compensating for Constituents A and B**

Constituent C is the element to be determined, but under the conditions illustrated, the concentrations of constituents A and B are so large that C cannot be measured at maximum sensitivity and accuracy.



**After Compensation for Constituents A and B**

This clearly illustrates the important advantages of current compensation . . . constituent C can now be measured with maximum accuracy and without the necessity for time-consuming chemical removal of constituents A and B.

- Accuracy; rapidity; the possibility of detecting and identifying minute quantities and of making simultaneous determinations of several components; small sample requirement; preservation of sample and permanent photographic recording of every analysis, are some of the reasons why the Heyrovsky Polarograph is so widely used.

The procedures established thus far by no means define the field of polarography — the perfected instrumental system of the Heyrovsky Polarograph creates unlimited possibilities for analytical and research applications.

A bibliography of more than 700 papers dealing with the polarographic method of analysis and a booklet discussing the Polarograph and polarographic analysis are available without charge on request.

The application of polarographic methods of analysis expands steadily. Some of the applications of the Heyrovsky Polarographs now in use are—Analysis of waters for trace constituents • Observation of deterioration of transformer oils • Detection of incipient lead poisoning • Organic research. Analysis of: Brass • Ferrous alloys • Lead alloys • Magnesium alloys • Nickel alloys • Zinc alloys • Metallic impurities in aluminum • Lead and zinc in paints • Major constituents in plating solutions • Ceramics and glasses • Raw materials for production of rubber • Vulcanized rubber for identification of specific ingredients • Foods • Paper ash and pulping liquors.

HEYROVSKY POLAROGRAPH
MODEL XII
MANUFACTURED BY
E. H. SARGENT & COMPANY · CHICAGO

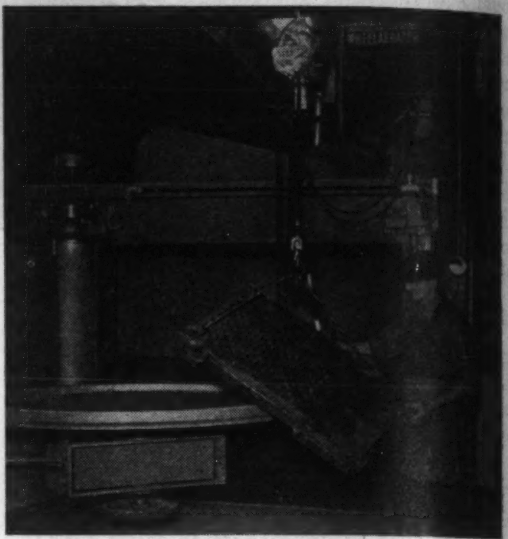
**S-29301 POLAROGRAPH—Heyrovsky, American Model XII, Indicating-Recording, With Current Compensator.** Complete with accessories. For operation from 115 volts, A.C. 60 cycle circuits ........................................ **$550.00**

E. H. SARGENT & COMPANY, 155-165 E. Superior St., Chicago 11, Ill.
*Michigan Division: 1959 East Jefferson, Detroit 7, Michigan*

**SARGENT**
SCIENTIFIC LABORATORY SUPPLIES

## Airless Abrasive Blasting Unit

With the addition of several new models of Wheelabrator swing tables, made by *American Foundry Equipment Co.*, 555 South Byrkit St., Mishawaka, Ind., industries having a moderate production covering a wide range of work to be cleaned are replacing compressed air blast rooms with these units. The table utilizes an airless abrasive blasting unit, and extends the speed and economy of airless blast cleaning to a wide range of intricate work formerly cleaned in air blast rooms in jobbing foundries and other metal working plants.



Four sizes are now available with single work table being 24 in., 66 in., 72 in. and 86 in. in diam. Work is placed upon a rubber-covered work table, which is mounted on the door of the blast cabinet. As the door is closed, the table swings into the cabinet underneath an airless blast unit. Then the table is rotated at a predetermined speed. The unit whips a continuous stream of abrasive down upon the rotating work to the full width of the table so that all surfaces are uniformly blasted to a bright, clean finish.

Only a very short exposure of parts is required. The door is then swung open and the part is turned over for cleaning on the underside.

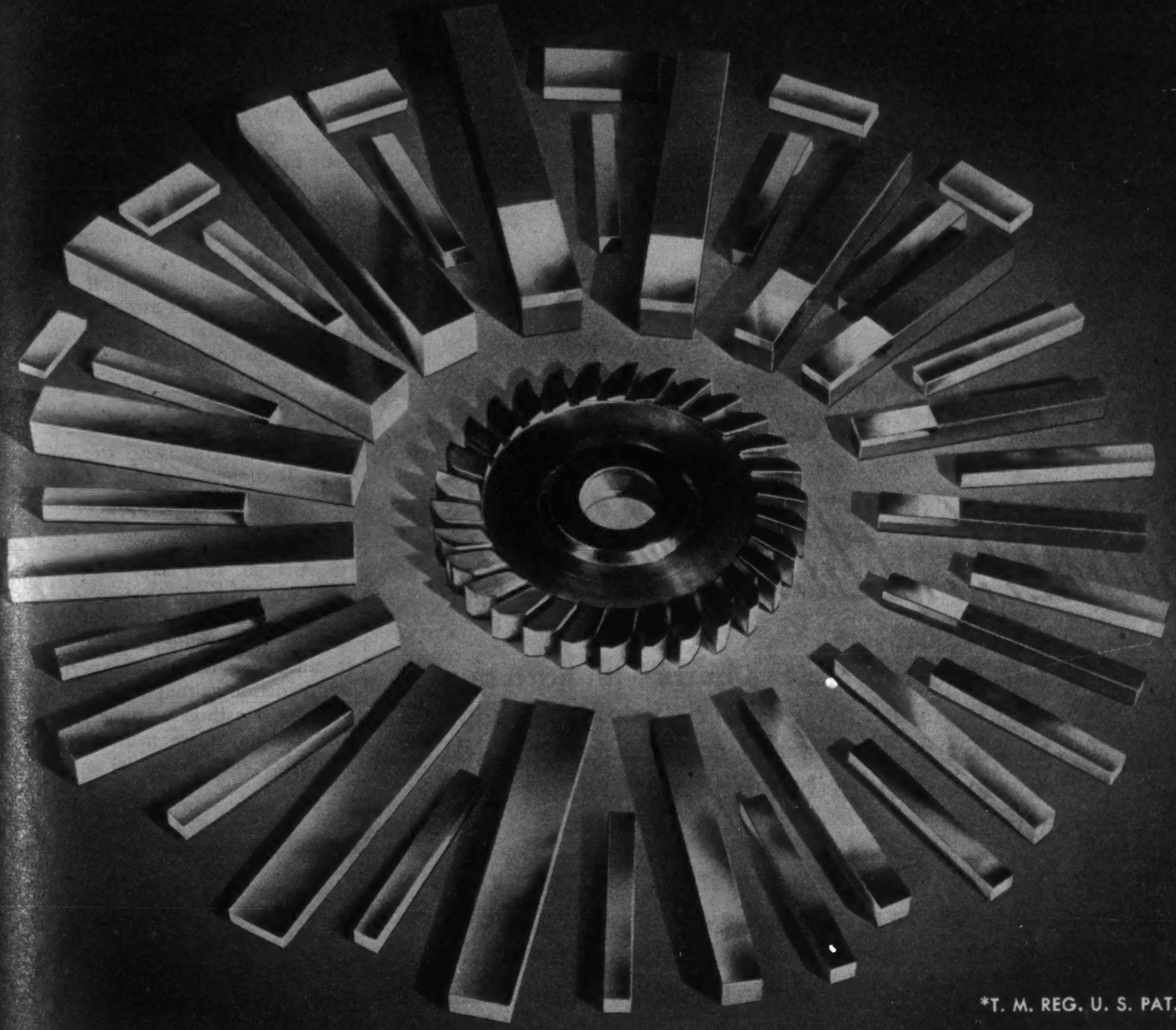
After striking the work, the abrasive falls through perforations in the table top into a hopper below the machine. A screw conveyor transfers the abrasive to the elevator boot section from which it is carried to an overhead abrasive separator. All broken down abrasive and useless fines are removed and the usable abrasive falls into a storage hopper for reuse.

All blast cleaning operations are within the cabinet and the operator is never exposed to the abrasive blast.

- A bench model, hand-operated positioner is handy for production and repair welding, assembly, overhauling, grinding, drilling, hard-surfacing, etc. on small work. Called Model 1H, it is made by *Ransome Machinery Co.*, subsidiary of *Worthington Pump & Machinery Corp.*, 1401 S. Second St., Dunellen, N. J. It has a tilting range of 150°, revolves 360°, and can be locked in position at any degree of tilt. The 16-in. table has $^9/_{16}$-in. slots.

# BORCOLOY*

FAST CUTTING FERROUS TOOLS



*T. M. REG. U. S. PAT. OFF.

*Announcing*

## THE CENTRIFUGALLY CAST BORON COBALT ALLOY

### FOR "MIDDLE-RANGE" MACHINING OPERATIONS

Extensive research in the field of cutting alloys has resulted in the centrifugally cast ferrous alloy that incorporates the superior Hardness of heat treated steel (Rockwell up to C-71) with the "Red Hardness" of Cobalt, and the "Wear and Abrasion Resistance" of Boron.

Tools of BORCOLOY cut tough and heat treated materials with feeds and speeds greater than those ordinarily obtained on "bottle-neck" production jobs —particularly so on the special aircraft and ordnance materials that present such a challenge today.

In order to meet these grueling demands with maximum efficiency, may we suggest you try BORCOLOY TOOLS under your most unfavorable conditions, and let their ability speak for themselves to remove more metal faster, with finer finish, at less cost per unit.

**GENERAL AIRCRAFT EQUIPMENT, INC.**

Tool Division; South Norwalk, Conn.

**Branch Offices: Newark Detroit Los Angeles**

**Canadian Sales: General Aircraft Equipment of Canada Ltd., Montreal, P. Q.**

THE BURRS CAME OFF . . .

QUICKLY . . . ECONOMICALLY

Yes, you can remove burrs with hard burring tools but how often do you take off too much metal? Or you can use a hand file or emery cloth but isn't that rather slow and expensive?

Why not do as White Engineering Company of Baltimore does on its many sizes and shapes of die-castings? It uses the Lea Method and properly selected Lea Compositions on flexible buffs and bobs. Why not burr, polish and buff as countless other plants?

Send us a complete description of the part or parts for which you would like our recommendations for more effective and cheaper de-burring or other finishing operations. Better yet, if possible, send us the parts. Our technical staff and laboratory will be glad to study your problem and make a complete report. If necessary, we'll send a representative to your plant.

THE LEA MANUFACTURING CO.

Waterbury 86, Conn.

Burring, Buffing and Polishing . . . Manufacturers and Specialists in the Development of Production Methods and Compositions

5-LM-10

## Specially Prepared Switch Copper

A specially prepared switch copper that eliminates hand-finishing of the metal before assembly and effects a great reduction in the rejections of the finished product has been recently placed on the market by *Revere Copper & Brass, Inc.*, 230 Park Ave., New York 17.

Manufactured by a process that brings new economy to the manufacture of switches and similar products requiring flat copper conductors having a minimum of contact losses, the new copper has a superior polish, which means lower losses at contact points of switches, knife blade fuses and exposed bus bars.

In the past such parts have been made of commercial bar, and it was necessary to resort to hand selection, sand blasting and wire brushing.

The new metal, which is just cut to length, drilled and assembled by the equipment manufacturer, has close tolerances that include no convexity when flatness is measured across the width of the bar; concavity 0.001 in. maximum per side up to 2 in.; 0.002 in. per side, 2 in. and over; camber, or depth of lengthwise arc, 1/8 in. max. in 8 ft. It comes in square or rounded edges.

● A 1-gal. autoclave, useful for metallurgical and chemical laboratories, is announced by *Industrial Machinery Co.*, Bloomfield Bank & Trust Bldg., Bloomfield, N. J. For instance, it is useful in experimenting with impregnation with pore-closing compounds of porous castings and metal powder parts. The autoclaves are made of stainless steel and other special metals.

## Roughness Meter for Shell Surfaces

A "roughness meter" that provides measurements of average roughness on extremely coarse surfaces such as shells, in the same manner as the Profilometer works on smoother machine surfaces, is announced by *Physicists Research Co.*, 343 S. Main St., Ann Arbor, Mich. It is particularly adapted to control of surface finish of high-explosive large-caliber shells.

Readings are directly in microinches of average roughness of the surface. The meter and scale selector provides full scale ranges of 300, 1000 and 3000 microinches. The

tracer is for hand operation, being heavier than the Profilometer tracer and with a blunt diamond point for tracing the surface, automatically self-adjusting to any curvature from 1½ in. O.D. to flat.

# THERMONIC

THE MOST EFFICIENT AND ECONOMICAL SYSTEM FOR INDUCTION HEATING

## "PUSH-BUTTON" HEAT

### *Speeds* FORGING—*Cuts* COST

The Thermonic Induction Heating process "beats the furnace to the punch." Button-controlled, it raises slugs to desired forging temperature almost instantly . . . delivers its work to the die one at a time . . . scale-free . . . automatically . . . at forge speed!

Other advantages . . . controlled temperatures . . . selective heating (important for upsetting) . . . simplified handling . . . increased output . . . reduced rejects . . . unskilled labor operation. Equipment is compact, requires no change in plant layout—conserves space—gives off no heat to the shop atmosphere.

Based upon their war performance—Thermonic generators for forging as well as for all metal treating operations promise significant product improvements for the plowshares of tomorrow. To help you meet the needs of your industry in the post-war's markets, our laboratory and development facilities invite the opportunity to sit-in and plan with you. Inquiries invited.

**INDUCTION HEATING CORPORATION**

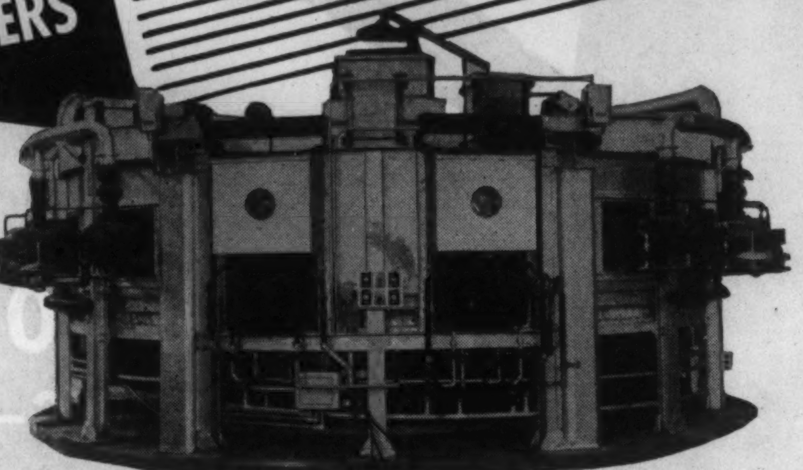
389 LAFAYETTE STREET, NEW YORK 3, N. Y.

**Largest Producers of Electronic Heat Treating Equipment for Forging • Brazing • Melting • Hardening • Annealing**

HAGAN

PERFORMANCE · UNIFORMITY · ECONOMY

DESIGNERS
AND
BUILDERS
OF



ROTARY HEARTH

FORGING FURNACES

Nearly 200 Hagan Rotary Hearth Forging Furnaces are setting new production and cost records for many of America's leading manufacturers. Accurate control of heating time and temperature insure a continuous flow of uniformly heated billets varying from 1"x 1" to 10"x 10" sections. Less heating time is required, fuel consumption is reduced in some instances as much as 58%, labor costs are lower, lost furnace time is negligible. These units are available in nine sizes from 4' to 26' hearth diameters with heating capacities from 600 to 20,000 lbs. per hour.

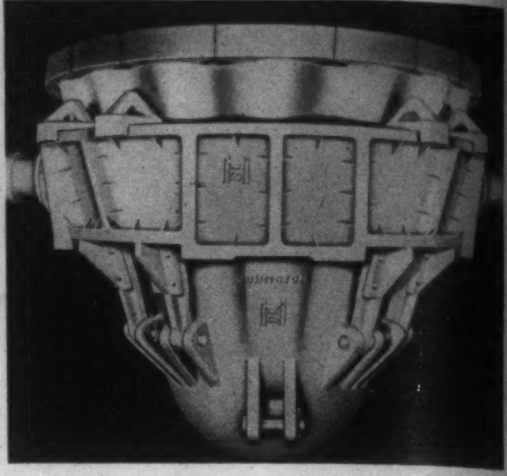
**Descriptive Bulletin will be sent on request.**

GEORGE J. HAGAN CO.
PITTSBURGH, PA.
Detroit Los Angeles Chicago San Francisco

FURNACES
FOR EVERY INDUSTRIAL NEED

## Cinder Pot

A corrugated cinder pot with new expansible rim that maintains the top of the pot in a true circle and prevents distortion, useful for open-hearths, but adaptable to all iron, steel and non-ferrous smelting plants, is sponsored by *Mackintosh-Hemphill Co.*, Pittsburgh. The tell-tale expansion joints in the rim indicate when the pot may be handled without danger by trunnion, bail ring or lifting lugs.



The pot in the accompanying photo, largest of its type ever made, weighs 44,000 lb., complete with supports, the lifting ring weighing 15,000 lb. The pot is 10 ft. 9 in. high, 11 ft. in diam. at the top, with 400 cu. ft. capacity. The improved type supports place most of the pot wall in compression, support the pot from its coolest point, and can be used on successive pot replacements.

These pots take the toughest beating of any steel castings in industry. Care is taken in annealing. Thermal stresses in the pot wall during dumping are almost as severe as during filling when the slag raises the inside surface from under 100 F. to over 2000 F. in a few minutes. Corrugations provide for expansion and contraction and quicker slag cooling. They may be given a copper coating in the bottom for easier dumping and skulling.

- A new line of plastic hammers for precise hammering with no danger of marring is announced by ***Industrial Products Suppliers***, 2 Broadway, New York 4. Called "Artus Red-Hed," the hammers are designed for tool makers, electricians on coil work, aircraft mechanics, etc.

## Bright Finish Atmosphere Furnaces

To meet the demand of tool rooms, experimental and moderate batch heating requirements for furnaces that provide correct heating with assurance of bright or clean surface finish, *W. S. Rockwell Co.*, 50 Church St., New York 7, has developed a broad range of "kleenmetal" oven-type protective atmosphere furnaces, designed for temperatures between 1200 and 2400 F. for bright annealing, silver or copper brazing, tool hardening, high-speed steel hard-

*(Continued on page 1458)*

MAGNESIUM IS TOUGH TOO

● When a sky riding "man o' war" lands — man — that's *impact!* Wheels have to "take it" but weight must be kept at a minimum. How is it done? Magnesium Castings! If you have designs which call for Magnesium Castings, Superior engineers will be glad to help you work them out. No obligation.

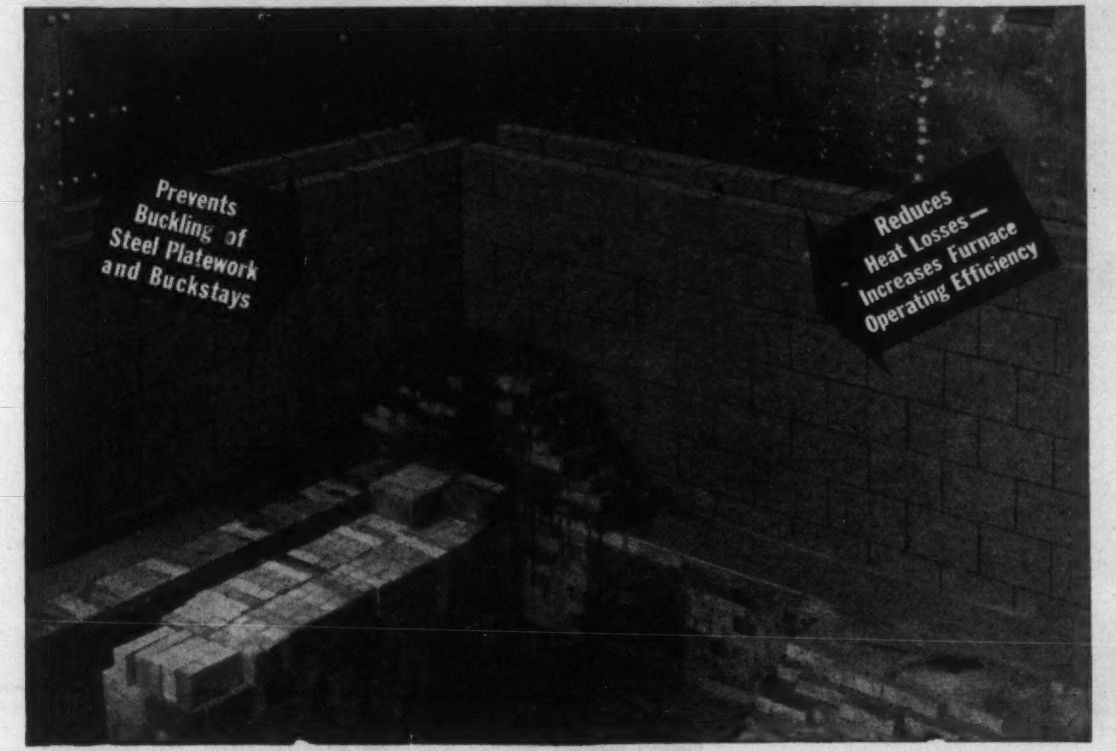
*Informative Booklet "Facts for the Designer"*
*Available Upon Request*

*Superior Magnesium Castings*

**DIVISION OF SUPERIOR BEARING BRONZE CO., INC. • 143 BANKER STREET • BROOKLYN 22, N. Y.**

*MAGNESIUM CASTINGS TO MEET U. S. ARMY & NAVY SPECIFICATIONS*

*This*
**LIGHTWEIGHT INSULATING BRICK**
*does "Double Duty"*
**in Furnace Walls**


Prevents Buckling of Steel Platework and Buckstays
Reduces Heat Losses — Increases Furnace Operating Efficiency

**CONVENIENT 13½ x 9" SIZE—EASY TO HANDLE**
**REDUCES WALL JOINTS 65%**

**Other forms of THERM-O-FLAKE INSULATION**

**Coating** —Seals and Insulates all types of furnace walls. Highly plastic, works and spreads easily.

**Blocks**—Highly efficient insulation where larger size units may be required.

**Concrete** —Monolithic castable insulation with high insulating value.

**Granules** —Loose-fill, efficient insulation, weighs only 6 pounds per cubic foot.

Protects furnace steelwork and plating from excessive heat with a strong resilient cushion which absorbs expansion stresses.

KEEPS HEAT INSIDE FURNACE WALLS

Excellent insulation,— a 4½ inch thickness being equivalent in heat flow resistance to more than 29 inches of fire brick.

Find out how quickly THERM-O-FLAKE Brick will pay back their cost in reduced furnace heat losses. For specific data, indicate type of furnace and approx. operating temperatures in writing to:

Illinois Clay Products Company
JOLIET, ILLINOIS

**Therm-O-flake BRICK**
FOR HOT FACE TEMPERATURES UP TO 2000° F.

ening, scale-free hardening, non-decarburizing heating or sintering powdered metals.

These batch furnaces, substantially lined, insulated and reinforced, are of two types: Those with carborundum or alloy muffles, and those which are heated directly. Muffle furnaces may be gas- or oil-fired; direct heated furnaces may be gas or electric. Both types are supplied with the means for introducing prepared atmosphere gas from separate generators or cylinders, or for producing, for certain operations, the desired atmosphere from controlled combustion of gas in the combustion chamber of the furnace.

For hardening and certain other heating operations, the long preheating chamber has a chute leading to a quench tank set in front of the furnace. For bright or clean annealing, brazing, sintering, etc., both muffle and direct heated furnaces are equipped with a water-jacketed cooling chamber for cooling the work in the protective atmosphere.

A heavy, self-sealing door inclined against the front plate of the furnace makes a tight contact to minimize heat and gas leakage. This door has a smaller swing-type door with a sight hole for observation of work and for loading or removing small pieces from the furnace without exposing a large area of the furnace to the atmosphere. Under the charging door (and the discharge door of the cooling section) there is a gas burner to provide a flame curtain which prevents air infiltration.

Furnaces with or without discharge chute are built with hearth areas of 8 in. by 12 in., 12 in. by 16 in., and 16 in. by 24 in. Furnaces with cooling chambers are built in five sizes from 8 in. by 14 in. to 27 in. by 36 in. hearths.

● A combination steel plate weight calculator and size selector is sponsored by the *Lukens Steel Co.*, Coatesville. Pa. Operating like a slide rule, it can determine quickly the theoretical weight of any steel plate from 10 to 200 in. wide and from 3/16 in. to 6 in. thick. With the size selector can be determined the longest and widest steel plate obtainable for any desired thickness. Included, is an imprinted table giving decimal equivalents and weights.

## Stretch Forming Machine

A comparatively new machine for stretch-forming parts, such as those for leading edges of airplane stabilizers, wing sections, etc., is announced by *Hufford Machine Works*, 207 N. Broadway, Redondo Beach, Calif. This model A-5 has smaller table and arms than other Hufford models, but will handle 60% of all aircraft parts that can be stretch-formed. Though smaller, it is one-third faster in its operating cycle.

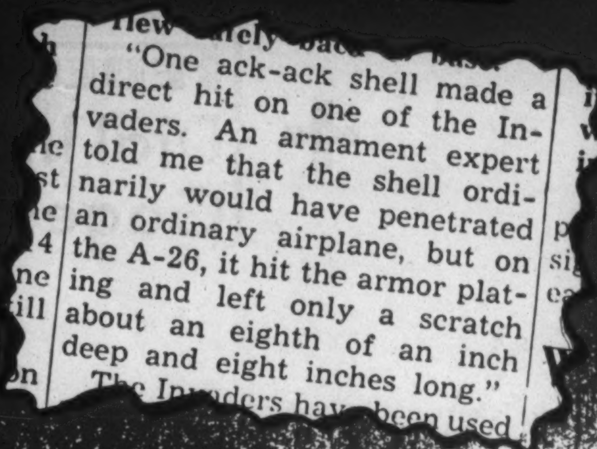
The die or form block can be made direct from the engineering drawing, thus reducing die cost sufficiently to pay the cost of the machine. It eliminates trial and error methods of correcting for springback, etc.

To prevent rotation of the jaws and facilitate loading and unloading, a jaw positioner is provided, which is easily removed when forming parts that finish up at a different angle than when first placed in the jaws.

How UP-TO-DATE are you on ALUMINUM?

TOUGH BABY MADE TOUGHER!

What happens when an A-26 gets hit by flak? Here's an excerpt from an on-the-spot report of a Douglas technician:



"One ack-ack shell made a direct hit on one of the Invaders. An armament expert told me that the shell ordinarily would have penetrated an ordinary airplane, but on the A-26, it hit the armor plating and left only a scratch about an eighth of an inch deep and eight inches long."

The Invaders have been used

A-26 INVADER—newest, fastest all-purpose bomber of the U.S. Army Air Forces, Douglas-built, designed to carry an extremely flexible selection of machine guns, cannon, bombs and fuel.

Official U.S. Army Air Forces Photo

TODAY:

R301 is Reynolds great armor plate alloy

TOMORROW:

**R301 is Reynolds great sheet and plate alloy, for high strength, toughness and easy workability**

HERE is a metallurgical triumph . . . an aluminum alloy so strong and resilient that it sheds flak . . . so light that it can be used to armor plate a fighting bomber like the A-26.

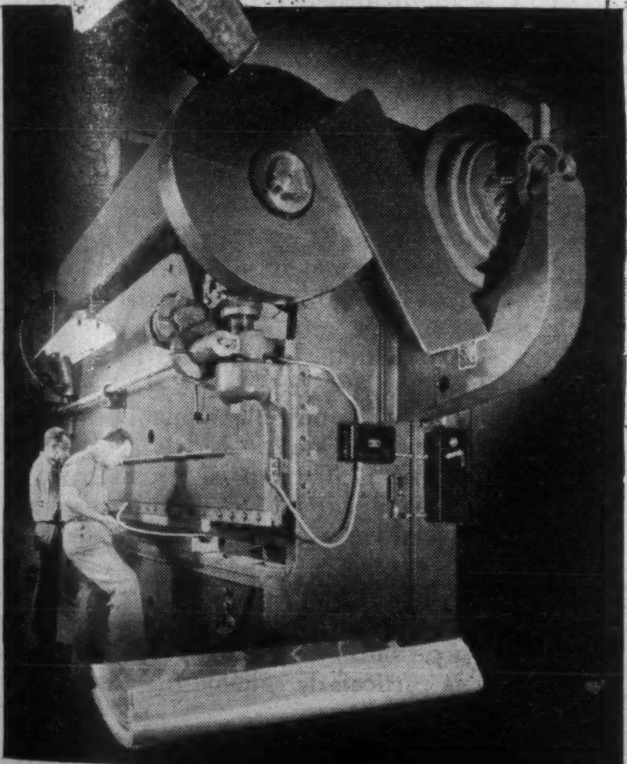
Adding toughness to the A-26 is a proud accomplishment, yet it is only one of many jobs R301 is doing for the fighting forces.

On land, on sea and in the air—in torrid heat, in sub-stratosphere cold—this great, high-strength Reynolds alloy has proved its tremendous versatility, setting the pace for broad peacetime applications.

R301 today leads the field in usefulness . . . reward for the pioneering spirit which distinguishes Reynolds and Reynolds engineers.

**Production-Wise** . . . R301—in solution heat-treated temper, is stable and more workable than any other high-strength aluminum alloy in the corresponding temper—thereby eliminates costly post-forming heat treatment and consequent distortion. Produced in three tempers.

See Reynolds catalog in Sweet's; also write for special bulletins on R301 and other Reynolds light-weight, high strength aluminum alloys. Reynolds Metals Co., Aluminum Div., 2518 S. 3rd St., Louisville 1, Ky.



**Giant press forms complete armor sections for America's war planes from R301, Reynolds great aluminum alloy.**

**Keep your dollars fighting . . . BUY MORE WAR BONDS**

7399-B A1-4

REYNOLDS METALS

REYNOLDS

The Great New Source of ALUMINUM

INGOT · SHEET · SHAPES · WIRE · ROD · BAR · TUBING · PARTS · FORGINGS · CASTINGS · FOIL · POWDER

DIMENSIONAL QUALITY CONTROL

+ FEDERAL Dial Indicator Gages

= Less Scrap Better Work

By Dial Indicator Readings at Production, *You Are Able to Determine WHEN Dimensions are Going "Out-of-Control"*

Federal Indicator Gages analyze the drift away from the dimensions specified.

FEDERAL Dial Indicator Gages *visualize* the progressive change, *during production*, in the dimension of the workpiece toward the Out-of-Control danger Zones. Thus you are forewarned when machine adjustments are about to become necessary.

Federal Dial Indicator Gages also enable you to obtain *accurate* Observation Readings for obtaining the Averages, Ranges, and other data necessary for making up the Control Charts. They eliminate guess work and enable you to obtain these readings more quickly with less chance of inaccuracies due to human variations in reading micrometers or other gaging instruments.

A Federal Gage, equipped with a Federal Dial Indicator, is a "natural" for Quality Control Engineers and their inspectors. Unlike the unreadable, conventional type gage, which shows only the go and no-go condition, it is possible with the Federal Indicator Gages to analyze the variation or drift away from dimensional requirements. In Quality Control parlance you obtain control, with Federal Indicator Gages, by Variables as well as by Attributes. Other type gages show *only* Attributes.

We have assisted hundreds of concerns in designing gages for controlling every type of dimension. Write our engineering department regarding your requirements. There is no obligation.

FEDERAL PRODUCTS CORPORATION • 1144 Eddy St., Providence 1, R. I.

★ ★ ★ ★ ★ FEDERAL ★ ★ ★ ★ ★

PRECISION MEASURING INSTRUMENTS

DIAL INDICATOR TRUISM—

Feeling a measurement is Relative

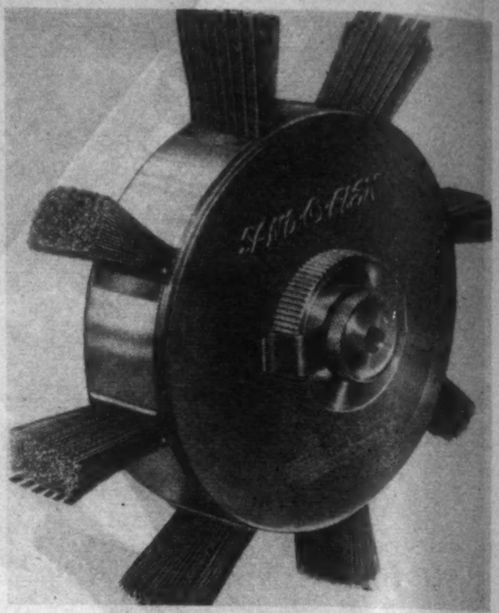
— Seeing it is Exact.

★ FEDERAL ★

## Brush-Backed Sanding Wheel

A brush-backed sanding wheel that sands, deburrs and finishes woods, metals, plastics, rubber products, etc., is sponsored by the *Exactone Tool & Die Co.*, 4373 Melrose Ave., Hollywood 27, Calif. It is adaptable to jobs formerly done only by hand and is called the "Sand-O-Flex."

The device consists of a central magazine, which houses the strip abrasive. Eight of these strips extend through the housing and are held against the work by tough bristles. The bristles "cushion" the abrasive, making it possible to get in and around corners, hollow and fluted surfaces, and small openings.



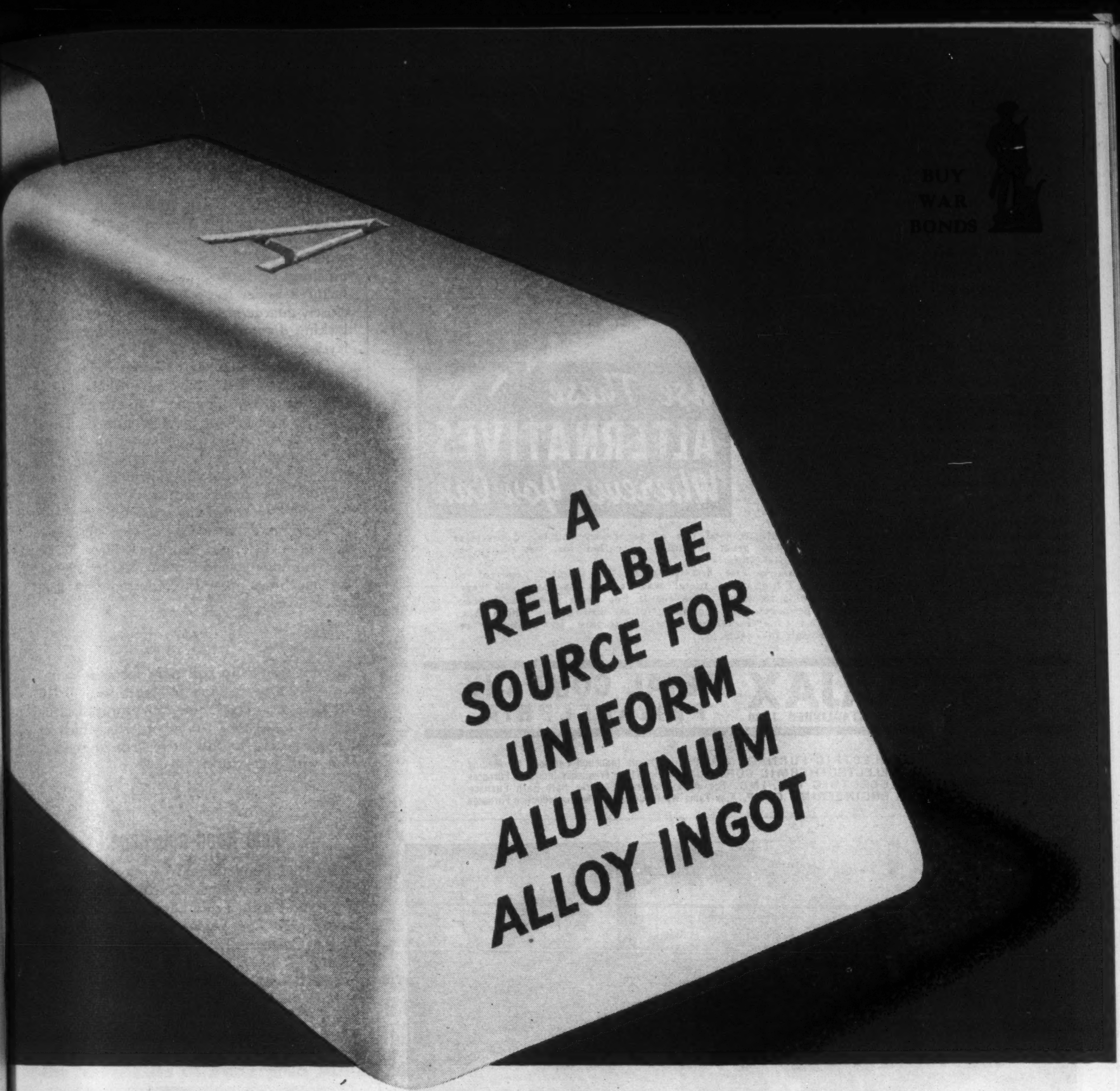
The body and cover are cast from "Zamak." Overall diameter (including brushes) is approximately 8 in. Weight fully loaded is about 2¾ lb. Normal loading contains 20 ft. of abrasive, and reloading is done simply by unscrewing the serrated nut and removing the cover.

A wide range of abrasives of various grits and grades are supplied. These cartridges, plus the quick-changing feature, permit the same tool to be used in all operations from rough stage to polished surface.

The Sand-O-Flex fits all standard ½-in. and ⅝-in. motor shafts, stationary or flexible, or can be supplied to fit almost any shaft size on request. A ¼-h.p. electric motor will handle all normal operations, as will most portable electric tools. Motor speed of 1750 r.p.m. is recommended, decreasing in proportion to the coarseness of the abrasive used and according to the results desired.

No particular skill is required to operate it, nor is much pressure necessary to obtain a good finish—the abrasive does the work. It is particularly suitable for use on a flexible shaft.

● Realizing the enormous heat-conducting quality of solid copper, the *Cleveland Industrial Tool Corp.*, 4713 Euclid Ave., Cleveland, announces diamond dressing tools set in solid copper shanks, as well as solid copper matrices. They not only throw off heat rapidly, but clamp the diamond more firmly in the setting. Too much heat tends to reduce the diamond's efficiency, loosens the stone in the setting and perhaps crack the stone.


A
RELIABLE
SOURCE FOR
UNIFORM
ALUMINUM
ALLOY INGOT
BUY
WAR
BONDS

Control aluminum alloy ingot impurities to an extent where they will not later cause trouble in casting, and the biggest single step has been taken to assure perfect castings.

The process of refining, governing every phase in production of Aluminum Refiners ingot, makes certain that these impurities are controlled. Uniformity of quality is thus assured.

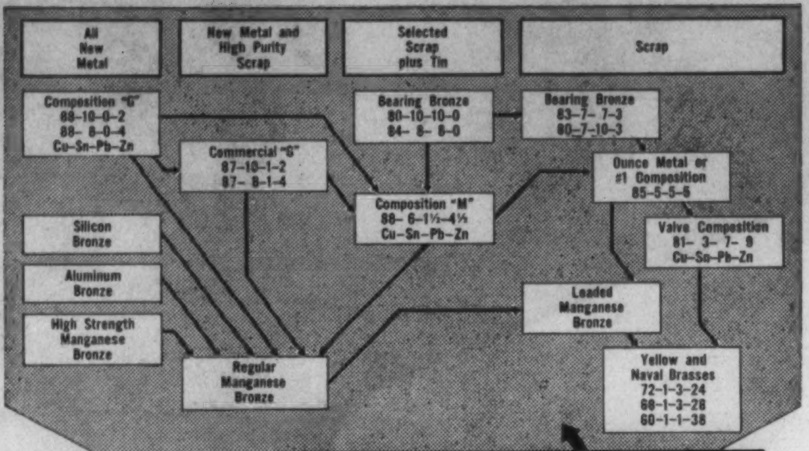
# ALUMINUM REFINERS

*Division of*

**BOHN ALUMINUM & BRASS CORPORATION • Detroit 26, Michigan**

*General Offices Lafayette Building*

**MANUFACTURERS OF ALL TYPES AND SHAPES OF CASTING AND DEOXIDIZING ALLOYS**


All New Metal
New Metal and High Purity Scrap
Selected Scrap plus Tin
Scrap
Composition "G" 88-10-0-2 88- 8-0-4 Cu-Sn-Pb-Zn
Bearing Bronze 80-10-10-0 84- 8- 8-0
Bearing Bronze 83-7- 7-3 80-7-10-3
Commercial "G" 87-10-1-2 87- 8-1-4
Ounce Metal or #1 Composition 85-5-5-5
Composition "M" 88- 6-1½-4½ Cu-Sn-Pb-Zn
Silicon Bronze
Valve Composition 81- 3- 7- 9 Cu-Sn-Pb-Zn
Aluminum Bronze
Leaded Manganese Bronze
High Strength Manganese Bronze
Regular Manganese Bronze
Yellow and Naval Brasses 72-1-3-24 68-1-3-28 60-1-1-38

NOTE

• "Proper Melting Decreases Foundry Losses," contains interesting data. Also, the booklet, "Nonferrous Ingot Metals of Today." Write for both of these. They are free.

●

*Send for booklet*
"INGOT METALS OF TODAY"

●

16 STANDARD INGOT METALS BY AJAX

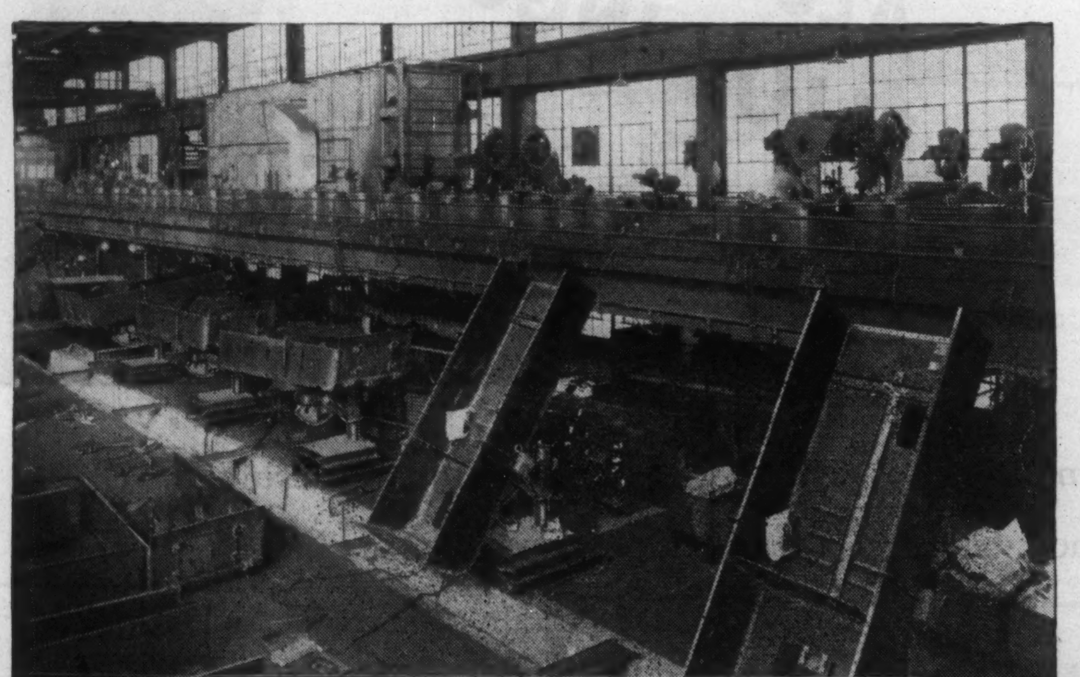
Ajax Tombasil
Ajax Plastic Bronze
Ajax Anti-Acid Bronze
Ajax Phosphor Bronze
Ajax Red Brass Ingots
Ajax Manganese Bronze
Ajax High-Tensile Manganese Bronze
Ajax Golden Glow Yellow Brass
Ajax-Hamilton Gear Bronze
Ajax Nickel-Copper 50-50%
Ajax Manganese Copper
Ajax Aluminum Alloys
Ajax Phosphor Copper
Ajax Silicon Copper
Ajax Nickel Alloys
Ajax Phosphor Tin

*Use These*
ALTERNATIVES
*Wherever You Can*

Notice how the arrows on the W.P.B. chart point to the *right*. . . . They show how alternative materials *currently available* can be utilized by foundrymen as now permitted by many designers. The purpose is to conserve primary metal at the mine through increased use of secondary ingots. Sometimes great ingenuity is called for, yet remember this:
The first program for scientific control of ingot metal was set up by Ajax 46 years ago. The result has been metal and practical technical follow-through in which Ajax increases your production by reducing rejects.

THE AJAX METAL COMPANY
ESTABLISHED 1880
PHILADELPHIA

ASSOCIATE COMPANIES:
AJAX ELECTRIC FURNACE CORP. Ajax-Wyatt Induction Furnaces for Melting
AJAX ELECTROTHERMIC CORP. Ajax-Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC. The Ajax-Hultgren Electric Salt Bath Furnace
AJAX ENGINEERING CORP. Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces



C-F POSITIONERS

Where a "Quick Change" is needed

• In production welding, which means working on top, bottom and on all sides of the weldment, a "Quick Change" of position is necessary for greater time saving, greater efficiency, greater safety to men and materials, and with resulting LOWER COSTS. A C-F positioner will do all this at the press of a button, without crane help or handling crews—it will rotate a full 360° at variable speeds from 0 R.P.M. up, tilt to 135° beyond horizontal, and permits welding, downhand, all sides, surfaces and angles in the one set-up with larger rods and fewer passes. All C-F positioners are pedestal mounted for maximum floor and work space—all are adjustable for height.

*Write for Bulletin WP-22*
CULLEN-FRIESTEDT CO.
1314 South Kilbourn Avenue Chicago 23, Ill.

## Dual Diamond Grinding Wheel

What is claimed to be two diamond wheels in one—a dual purpose super-cut zurium bonded wheel—is announced by *Industrial Abrasives, Inc.,* 3724 W. 38th St., Chicago 32. The maker says that this is the first time in tool grinding history that it has been possible to make such diamond wheels, both for rough grinding and fine finishing of cutting tools. They are manufactured under the company's exclusive and closely-guarded secret process of securely locking diamonds in the matrix, layer upon layer.

Of the two separate grinding surfaces, the outer (7 deg.) beveled surface contains layers of coarse diamonds whereas the inner flat surface is built up of fine diamonds (400 mesh). By merely angling the side or point of a carbide tool, it can be rough ground, and super fine-finished in 6 sec. without the operator having to shift his position. No wheel change-over is required.

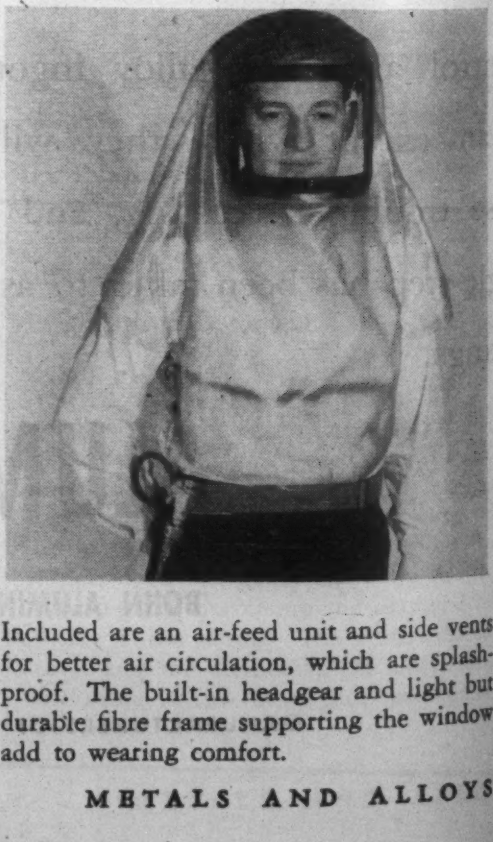
Better tool grinding results, and tools stay sharper longer and last longer by being fine finish ground. Also, less tool grinding machines may be required and floor space saved.

● Magnesium in coil strip form in widths from ¾ to 5 in. and in gages from 0.010 in. as thin as 0.005 in. can be supplied by *Burgess Battery Co.,* Freeport, Ill., which set up machinery to roll such strip in connection with war work.

## Acid Hood and Cape

An acid hood that gives chemical workers protection against all concentrations of strong and mild acids have been developed by *Chicago Eye Shield Co.,* 2300 Warren Blvd., Chicago 12. Inorganic and many organic acids have no deteriorating effect on the hood.

It is made of "Cesco Acitex." The acid-proof clear window provides normal vision. The hood covers the head, shoulders, chest and back, and is snugly tied at the waist.



Included are an air-feed unit and side vents for better air circulation, which are splash-proof. The built-in headgear and light but durable fibre frame supporting the window add to wearing comfort.

# ECLIPSE OF THE RISING SUN!

The day has come! The skies are black over Tokyo—black with American bombers—bombers that will blast the Jap sun out of the heavens and off the face of the globe.

Helping to bring this hour of triumph ever closer are the ten plants of Federated Metals supplying vast quantities of aluminum, brass, bronze, die-cast alloys, solder, babbitt and zinc dust to the manufacturers of the "sinews of war."

Wartime production has increased the use of nonferrous metals. Federated has kept pace with this development by producing alloys of superb quality. The improved technique gained in producing for war is your guarantee of continuing quality when peace comes.

Federated
METALS DIVISION
FMD
AMERICAN SMELTING
& REFINING COMPANY
120 BROADWAY, NEW YORK 5, N. Y.
Nation-wide service with offices in principal cities

R-S

QUALITY PRODUCTS SINCE 1908

A Sign of

R-eliable S-ervice

This R-S name plate on an industrial heat-treating furnace is more than a means of identification—it is the stamp of approval of R-S engineers.

It guarantees top notch production due to proper design, construction and operation.

It guarantees that the entire equipment is geared to individual plant conditions and the type of heat-treated product involved.

It assures minimum fuel consumption and the conservation of manual effort with maximum safety.

For heat-treating efficiency and economy, today or tomorrow, specify R-S Industrial Furnaces.

Consult with the nearest R-S District Office.

**R-S Products Corporation**
631 Fisher Building
Detroit 2, Michigan
**Phone—Trinity 2-2760**

**W. R. McDonough & Co.**
Cleveland Railway Bldg.
Cleveland 14, Ohio
**Phone—Prospect 1940**

**Haylett O'Neill**
P. O. Box 1662
Houston, Texas
**Phone—Hadley 9704**

**A. Perry Roberts**
Woolworth Bldg.
New York 7, N. Y.
**Phone—Barclay 7-1245**

**Harry M. Wood**
800 Times-Star Tower
Cincinnati 2, Ohio
**Phone—Cherry 2421**

**S. P. Kinney**
233 Oliver Avenue
Pittsburgh, Pa.
**Phone—Atlantic 1790**

**F. G. Dunbar & Son**
53 W. Jackson Blvd.
Chicago 4, Illinois
**Phone—Wabash 1104**

R-S Furnaces of Distinction

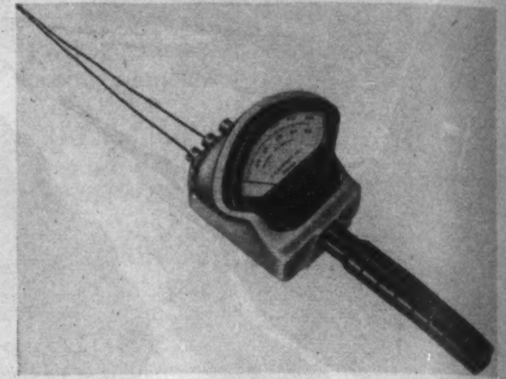
FURNACE DIVISION
R-S PRODUCTS CORPORATION

4522 Germantown Avenue • Philadelphia 44, Pa.

BUY WAR BONDS

## Light Portable Pyrometer

A portable pyrometer, weighing 1¾ lb., with revolutionary design features, adapted to reading temperature of molten metals, exclusive of ferrous metals, hot air or liquids and for hot surfaces, if used with the prod-type thermocouple, is announced by the Instrument Div., *K. H. Huppert Co.*, 6830 Cottage Grove Ave., Chicago.



The scale is elevated to an angle that offers maximum reading ease in all working positions and minimizes side reflections on the scale glass. The glass is partially protected from other objects, with breakage minimized.

The instrument provides accuracy of reading to 2% of scale range. The duo scale is standard with readings of: 0 to 500 F. and 0 to 1000 F., —0 to 750 F. and 0 to 1500 F., or, 0 to 1000 F. and 0 to 2000 F., or equivalent deg. C. Other scales are available on special request. Manual room temperature adjustment can be made by the zero adjustment screw on the face of the motor.

A sturdy 6-in. handle permits a firm, comfortable grip. Light weight reduces wrist and arm fatigue to a minimum.

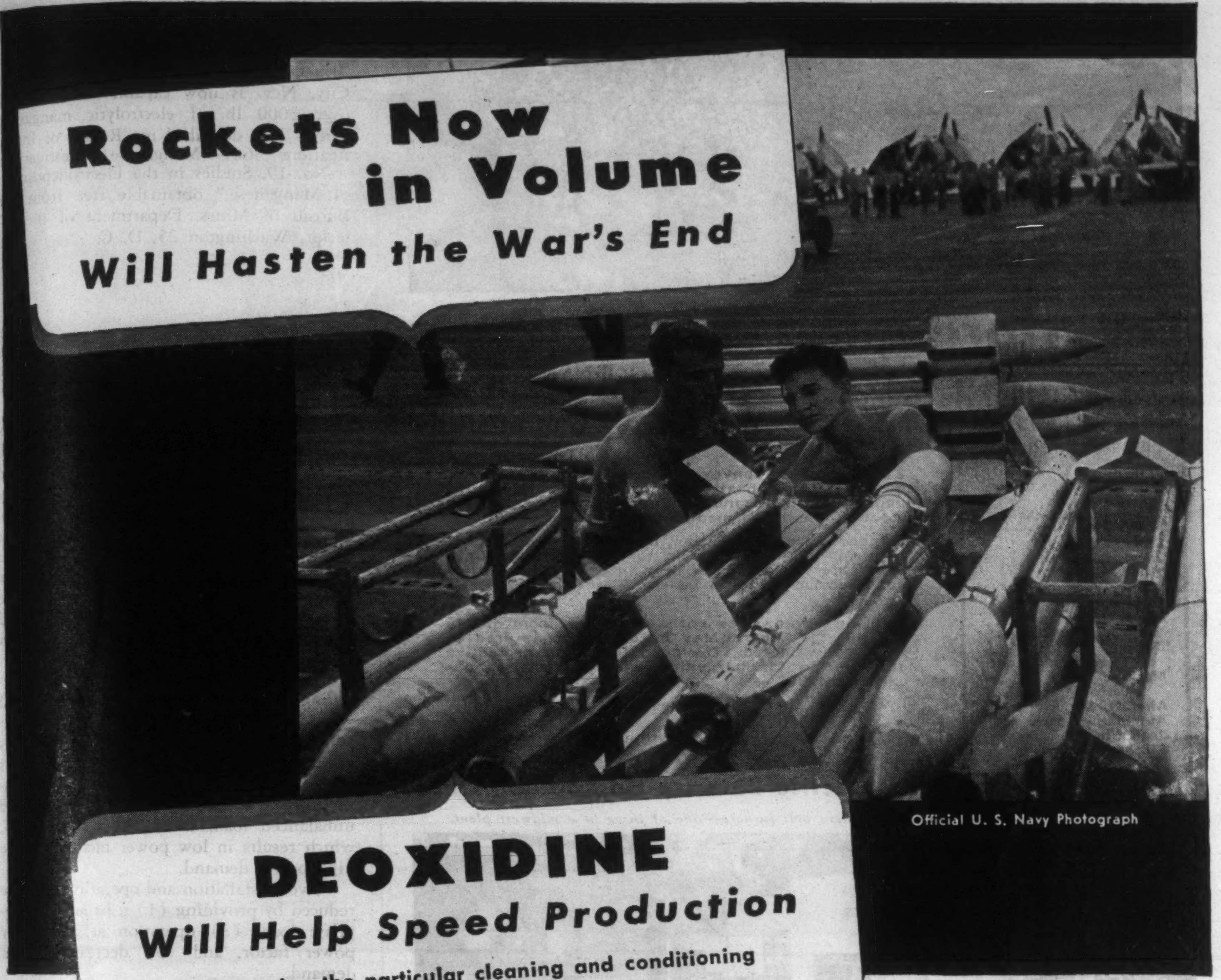
## Sealant for Porous Castings

A castings sealant in the form of a thermosetting impregnating solution, called the X-100 series, is announced by the *Plastics Div., Monsanto Chemical Co.*, Springfield 2, Mass. It is furnished as a mixed solution or as a base resin to be mixed with styrene monomer.

Of the mixed solutions, X-117 is particularly suitable for magnesium, X-118 for aluminum and magnesium, and X-119 tentatively for iron. This number identifies an XR-146 resin with a viscosity of 16.

With the application of heat the liquid first gels and then cures to a rubbery solid. The base resin cross links with the styrene monomer to form a thermoset product. Mixed resins are stable for 3 months at room temperature. The X-100 series are to replace scarce tung oil.

The cured resin is a somewhat rubbery non-porous solid, insoluble in aromatic gasoline, lubricating oil, ethylene glycol, isopropyl alcohol, and water. It has good thermal stability. In either cured or uncured form it does not attack magnesium or ferrous metals. When the polymer is cured within the porous structure of the casting, very little surface is exposed to fluids coming in contact with the casting.



# Rockets Now in Volume Will Hasten the War's End

Official U. S. Navy Photograph

# DEOXIDINE

## Will Help Speed Production

**Overcoming the particular cleaning and conditioning problems incidental to the type of metal used in Rockets**

There is a type of **DEOXIDINE** to meet cleaning and conditioning specifications for Rockets of the various sizes, ranges and destructive effects used throughout the U. S. Armed Forces.

The special difficulties which have arisen in cleaning the unusual type of rocket metal have been met and solved by ACP technicians who will be glad to advise with you and suggest the type or types of **DEOXIDINE** and process best suited to your individual needs.

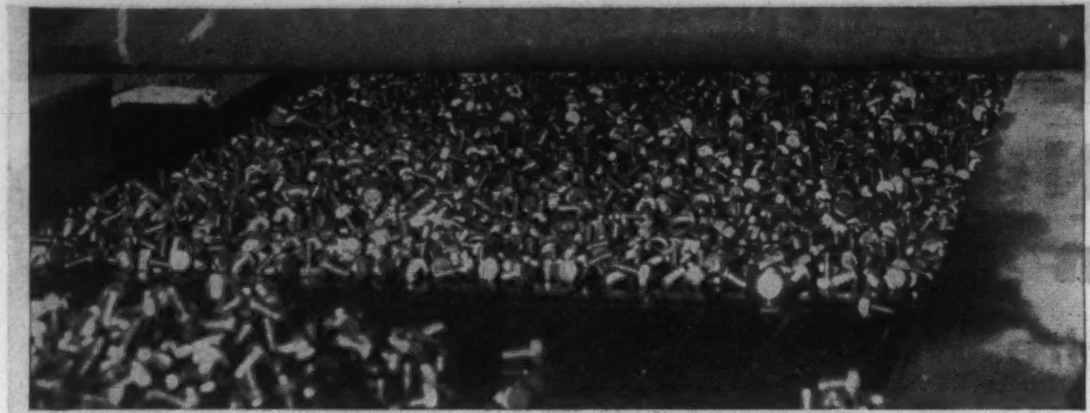
**PEROLINE** should be used by subcontractors as their shipping oil. Peroline not only protects the parts in transit, fabrication and storage, but also has the ability to remove light rust and rusters and when the work is vapor degreased leaves the surface properly conditioned for durable paint finish.

The experience of the ACP laboratories and of ACP technicians is at your service in planning equipment and adapting our products to your particular production problems.

MANUFACTURERS OF INHIBITORS AND METAL WORKING CHEMICALS

**AMERICAN CHEMICAL PAINT CO.**
AMBLER ACP PENNA.
G-5

*Note—West Coast Plants may address inquiries and orders for prompt delivery to Leon Finch, Ltd., 728 East 59th St., Los Angeles, California.*



For Hardening Small Parts

175 to 2000 lbs. per hour

Uniformly—Scale-Free—Continuously

Products being treated in EF Chain Belt Furnaces, include:

Sprockets
Cap screws
Bolts and nuts
Gears and pinions
Flat springs
Coil springs
Small forgings
Valve springs
Spring plates
Tractor links
Rivets and washers
Wrench & tool parts
Bearing parts
—cups and cones
Machine gun cartridge clips
Aircraft engine parts
Automotive parts
Rock bits, and many other products

EF Chain Belt Conveyor Furnaces are dependable, general purpose heat treating units for the continuous, uniform, economical, production heat-treatment of small and medium size products.

Hundreds are in operation, handling products ranging from small springs up to heavy crawler links for tractors. Some have been in practically continuous service 10 to 15 years. Maintenance cost is low.

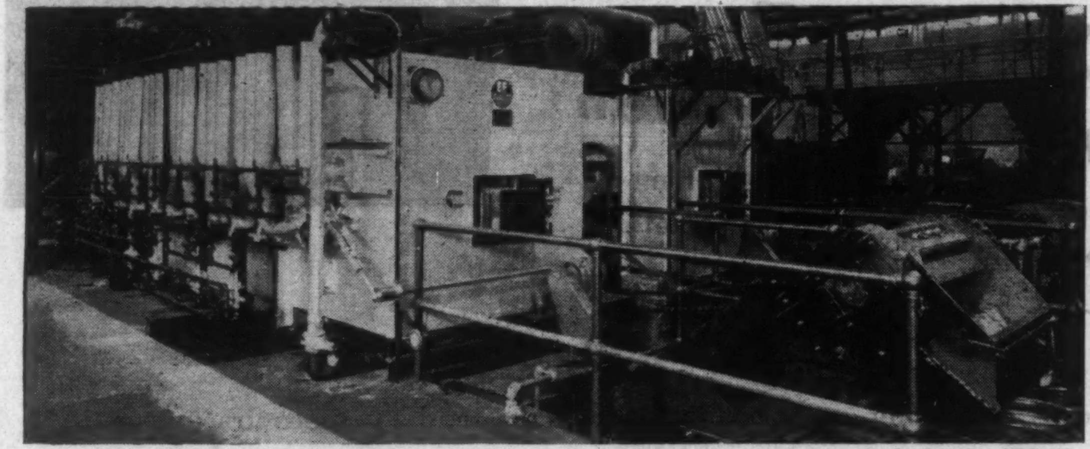
Built in seven sizes with capacities from 175 to 2000 lbs. per hour. May be oil-fired, gas-fired or electrically heated. Designed for using protective atmospheres for hardening without scale or decarburization.

Investigate their advantages.

Send for circulars showing the chain belt and other types of EF production furnaces.

The Electric Furnace Co., Salem, Ohio

(Below) An EF gas-fired radiant tube chain belt furnace—one of three in a midwest plant.



For Production Furnaces

For Handling Products in any Shape or Size

FURNACES OIL, GAS or ELECTRIC

For Every Heating and Heat Treating Process

Aluminum Brazing
Annealing
Billet Heating
Bright Annealing
Bright Hardening
Copper Brazing
Controlled Atmosphere
Carburizing
Drawing
Enameling
Forging
Hardening
Malleablizing
Silver Soldering
Nitriding
Normalizing
Soaking Pits
Scale-Free Hardening
Quenching Machines
Ceramic Kilns, etc.
Process Heating

ELECTRIC FURNACES FUEL FIRED

We Build the Furnace to Fit Your Job

THE ELECTRIC FURNACE CO.
SALEM, OHIO

For Production Furnaces,
For Any Process or Production

Consult EF Engineers

● Extensive research has made possible the production of virtually pure electrolytic manganese at lower cost, the *Bureau of Mines* reveals. Its pilot plant at Boulder City, Nev. is now capable of producing over 2000 lb. of electrolytic manganese daily. It is described in "Report of Investigations 3681—Manganese Investigations—No. 19, Studies in the Electrodeposition of Manganese," obtainable free from the Bureau of Mines, Department of the Interior, Washington 25, D. C.

## Three-Phase Resistance Welder

A new principle for the spot welding of steel in heavy gages with a balanced three-phase load has been anncunced by *Sciaky Bros.*, 4915 W. 67th St., Chicago.

All three phases of the a.c. line current are rectified to d.c. and supplied to the welding transformer through a system of reversing ignitron tubes, which allow the current to pass through the center tapped primary first in one direction, and then in the other. Thus, the induced welding current in the secondary is a continuous alternating impulse of low frequency—of ideal wave shape and magnitude.

This system helps overcome limitations encountered, where single phase a.c. welders are subject to heavy loads. These are: disturbance to the usual 3-phase supply by the unbalanced load, the heavy reactive load, which results in low power factor, and the high power demand.

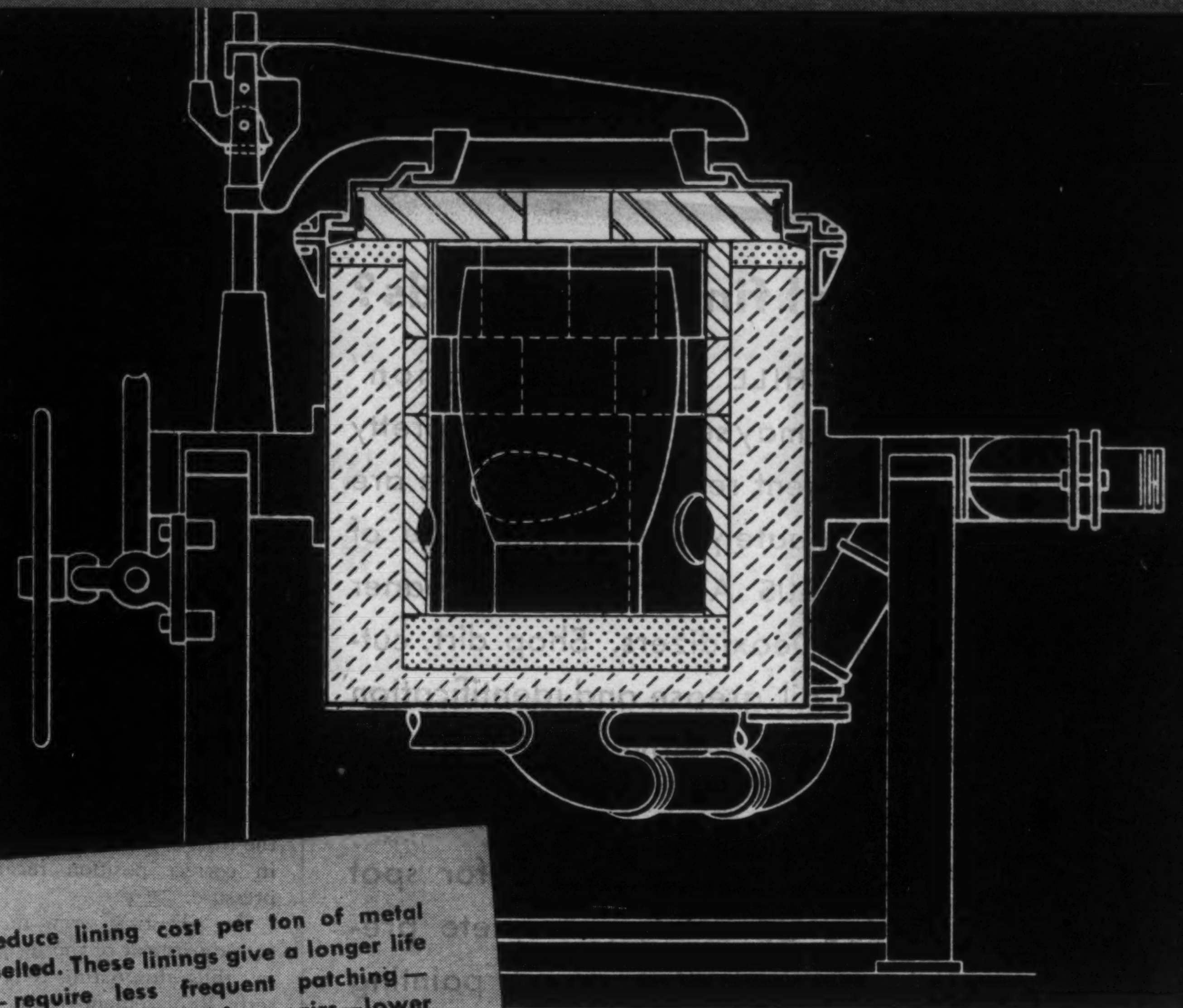
Power installation and operating costs are reduced by providing (1) a balanced three-phase load, (2) operation at near unity power factor, and (3) decreased power demand.

A typical spotwelder employing the "Three-Phase" principle (type PMCO.2T-4) is rated 100 KVA at 50% duty cycle and operates at 85% power factor. A preheating current and variable pressure are provided. Capacity on mild, scaly or stainless steel is from 0.032 in. plus 0.032 in. up to and including 0.312 in. plus 0.312 in. Speed on two thicknesses of 0.062 in. is 90 spots per min.

The principle has been effectively applied to seam welders for aluminum, heavy duty projection and flash welders.

● A new 25-ton, self-contained plain hydraulic press is announced by *Watson-Stillman Co.*, Roselle, N. J. It is of 4-rod construction with "moving down" ram and double-acting cylinder. Operating pressure is 1000 p.s.i., 10-in. stroke, a 15 by 15 in. platen and 20 in. daylight opening. Diameters are: Cylinder, 8 in.; ram, 7¼ in. Pressure is from a high and low pressure vane type radial pump direct driven by a 5-h.p. motor. A hand lever works a 4-way valve control to vary the load from 15 to 25 tons. Speeds are: Advance, 103 in. per min.; pressing, 20 in. per min.; return, 114 in. per min.

# 5 WAYS TO LOWER OPERATING COSTS



1. Reduce lining cost per ton of metal melted. These linings give a longer life—require less frequent patching—shorten time needed for repairs—lower maintenance expense.
2. Provide easy and rapid installation even with inexperienced labor. The "CARBOFRAX" tile have rugged, interlocking joints—are made accurately to size—insure lower installation costs.
3. Permit use of heavier insulation. The additional insulation made possible by the "CARBOFRAX" lining being only 1¾" thick reduces heat loss through the furnace wall—decreases fuel consumption.
4. Assure low heat-capacity furnace structure. This means faster melting rates—decreased fuel input—greater production.
5. Maintain original diameter. The melting rate remains constant. Crucible life is improved.

## . . . assured with "CARBOFRAX" linings

In hundreds of crucible type non-ferrous melting furnaces of both tilting and stationary designs "CARBOFRAX" silicon carbide linings are regularly giving the results listed on the left.

Most of the advantages result from the high refractoriness, excellent resistance to spalling, cracking and flame erosion and high hot strength of "CARBOFRAX" linings. Ask our Refractories Engineer to fully explain the merits of these linings for your melting furnaces.

**THE CARBORUNDUM COMPANY**
**Refractories Division**
**Dept. O-3**
**Perth Amboy, New Jersey**

*"CARBORUNDUM" and "CARBOFRAX" are registered trade marks of, and indicate manufacture by, The Carborundum Company.*

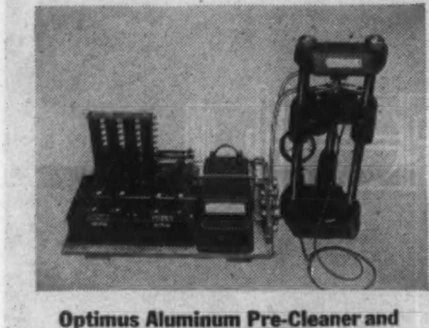
**Super Refractories by CARBORUNDUM**
TRADE MARK

DOES THIS SPECIFICATION

DUAL PROBLEM:
1. To produce low surface resistance on aluminum preparatory to spot welding.
2. To place aluminum in condition for alrok and anodizing and painting.

RESULTS DESIRED:
Smut-free surface.
Oxide removed using a cold solution.
Negligible weight loss.
Minimum machine adjustment.
Minimum handling.

. . . fit your metal finishing needs?



Optimus Aluminum Pre-Cleaner and Deoxidizer are backed by extensive research and test utilizing the latest scientific equipment.

WHILE this "specification" may seem to establish pretty stringent requirements, these are adequately met with the use of OPTIMUS Aluminum Pre-Cleaner and Deoxidizers. Shop dirt, cutting oil, grease and identification paint are easily and completely removed in the proper pre-cleaning operation.

Not only is the aluminum properly prepared for spot welding, but, as an added advantage, complete preconditioning for alrok and anodizing and painting is likewise accomplished. With OPTIMUS methods all classes of alloys are easily handled.

This is typical of the way OPTIMUS Detergents* and Processes are ready to go to work in your metal finishing operations . . . ready to bring you the additional advantages which come from their use.

* Available in Alkaline, Acidic, Solvent and Emulsion types.

Let Dependable
Optimus Detergents
and Processes Solve Your Problems in These and Other Related Operations
- Cleaning metal before finishing
- Preparation for welding
- Ball Burnishing
- Stripping for refinishing
- Cleaning for Maintenance and Inspection

* * *

- In Hand or Machine Operations
- In Metal Washing Equipment
- Cold or Heated Tanks
- Steam Cleaning Machines
- Spray, Dip or Soak Operations

OPTIMUS DETERGENTS COMPANY
136 CHURCH ST., MATAWAN, N. J.
ENGINEERS AND MANUFACTURERS

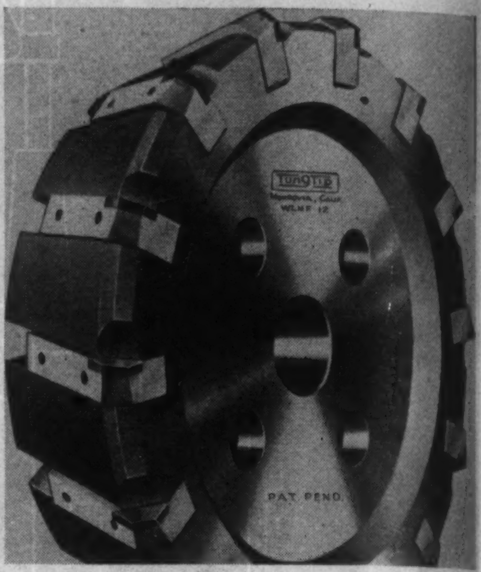
WRITE FOR YOUR COPY of new Bulletin 4D1 and full details regarding these processes and materials.

OPTIMUS DETERGENTS
FOR INDUSTRY

## Inserted-Tooth Milling Cutter

With increase in production of 200 to 500% in milling with carbide tools, there is increased demand for absolute rigidity in the machine tool, working fixture, workpiece and the milling cutter. With this in mind, there has been developed a new inserted tooth milling cutter, the "Tungtip," made by the *Tungtip Div., Lowell & Grayson*, Monrovia, Calif.

The cutter consists of carbide-tipped inserted teeth rigidly locked into the tool body without extraneous parts. These inserts are provided with a precision flat back and serrated front face, which assures uniform clamping pressure over the entire length of the insert. This locking maintains the blade in correct position regardless of cutting pressure.



An adjusting screw mechanism provides for adjustment of the insert to within 0.003 in., thus eliminating rough grinding of inserts. Replacement inserts are provided with the face of the carbide finish ground and the cutting edges rough ground to reduce user's maintenance cost. The cutters are available in face mill and half-side mill styles.

The alloy steel body of the face mill is accurately counterbored in the back of the cutter, providing a ground surface for accurate location on the outside of the spindle nose of the milling machine. Half-side mills are provided with a precision ground arbor hole and hub faces for accurate alignment for straddle milling operations.

Both types of cutters are available from stock with carbide teeth ground with corner angle, or may be had with inserts ground to 90 deg. corner for milling to a shoulder.

● An inexpensive wire stripper for cleaning cotton, enamel, silk, string asbestos, etc. off metal wire is announced by the *Ideal Commutator Dresser Co.*, 1928 Park Ave., Sycamore, Ill. Round, flat or rectangular wire, solid or stranded, may be stripped. Two wire cleaning brushes are positively driven, mounted directly on the end of separate motor shafts. One brings the upper brush down against the wire and the lower brush—between the two rapidly turning brushes, and the wire is quickly cleaned. The strippings are removed by a dust collector.

*(More News on page 1472)*

ORDER NOW

# KOLD-GRIP

## GRAIN CEMENT

*for setting up*

## POLISHING WHEELS

★ Park Kold-Grip Grain Cement is an ideal binder for setting up any size polishing wheel, for cementing polishing wheel sections together or for recoating abrasive belts and discs. Expertly compounded from a silicate base mixed with organic and inorganic fillers. Available in different grades for various types of polishing operations. Write us today for descriptive literature.

KOLD GRIP GRAIN CEMENT
Park
378
Park
CHEMICAL COMPANY

### *Advantages*

1. Clean, odorless and no bacterial attack.
2. No heating required.
3. Economical since cement heads will cut faster and polish more pieces per wheel before reheading is necessary.

**Park**
**PARK CHEMICAL CO.**
DETROIT . . . MICHIGAN
8074 MILITARY AVENUE

### Park INFRA-RED DRYER

With this portable Infra-Red Dryer, it is now possible to dry polishing wheels in minutes instead of hours after application of "head". This means a definite saving of production time. You can cut down on your wheel inventory by using the same wheels more than once in a single day. Write for specifications and prices.

When Tomorrow
Demands Lighter,
Stronger Metals

CERIUM

will play a
Leading Role

As an alloying agent for ferrous and non ferrous metals, CERIUM* will assume great importance in post war metallurgy.

Current research indicates that the industrial possibilities of this useful element are vast and the surface of our knowledge has, as yet, scarcely been scratched.

Investigate CERIUM

***CERIUM STANDARD ALLOY**

Containing 45-50% Cerium — Balance
principally rare earth metals.

***Also available***

**CERIUM MASTER ALLOYS**

*with*

ALUMINUM • CARBON • COPPER • GOLD
IRON • LEAD • MAGNESIUM • MANGANESE
NICKEL • SILICON • SILVER • TIN

*OTHERS ON REQUEST*

*The Source for Facts about Cerium*

**CERIUM METALS
CORPORATION**

522 FIFTH AVENUE
NEW YORK 18, N. Y.

## Stretch-Leveling Table

A new hydraulic stretch-leveling table, for permanently straightening and leveling long narrow metal sections that are twisted, bent or otherwise distorted after rolling or heat treatment, has been announced by *Hufford Machine Works, Inc.*, 207 N. Broadway, Redondo Beach, Calif.

It will straighten rolled and extruded metal used for aircraft fuselage stringers, railroad car structural members, bus body parts, boat frames and similar structural parts that must be straightened prior to forming or degreasing operations.

It handles sections up to 40 ft. long of any shape and many materials. It not only straightens the stock by establishing a "set" in the metal through a slight pre-determined stretching of the material, but also can be used with a die for stretch-forming the workpiece to contours up to 30 deg. The machine has a pull capacity of 40 tons with a 19-in. stroke on each hydraulic piston, but it can be built in higher or lower capacities to meet the varying requirements of straightening work.

## Plants and Slants

Stockholders of *Allegheny Ludlum Steel Corp.* were asked to comment on the company's annual report and managerial policies. A questionnaire was sent them late in December; by Feb. 15 returns covering 27% were tabulated. There was marked demand for information on 1945 outlook and on dividend policies and earnings, but less interest in contract termination, depreciation policies, renegotiation of contracts, or inventories. They showed strong faith in the future of alloy steels and value of intensive metallurgical research. Executive compensation often was the object of barbed comment. As to annual reports, they want 'em short, clear, simple, easy to understand. They want pictures of products and plants —nix on employees and management.

---

The *Allegheny Ludlum* report stressed the backlog of demand accumulating for light weight, high alloy and stainless steels for post-war. The company ranks eleventh in the steel industry in dollar volume. The company has developed a new forgeable material for gas turbines and jet propulsion. Two other similar alloys have been developed, one for aircraft engine valves and the other for turbo-superchargers. The company will produce a new series of magnetic alloy steels discovered by *Western Electric Co.*

---

The first Distinguished Service Award ever given any employee of *Lukens Steel Co.*, or subsidiaries, was recently awarded to Peter Cavaloff for courage above and beyond his duty on the production front. When his foreman tried to change some fuses in a switchbox he contacted 440 volts, from which he could neither release himself nor call for help. Cavaloff placed his hands beneath the foreman's shoulders and

# HOW TO GET A STEADY STREAM OF RELIABLY BRAZED PARTS *with* SIL-FOS *or* EASY-FLO

*At left* — Adapter, EASY-FLO wire ring and hand grenade body. Bodies are carried on a simple conveyor, first through a liquid degreaser and then past stations where they are progressively fluxed, adapters are inserted and EASY-FLO rings are preplaced. Assemblies then enter the heating section where they are rotated as they move along.

*At left* — The rotating assemblies are carried between two rows of gas-air burners. Time per body through the heating section—only 63 seconds. Production is 660 per hour, with the human element eliminated from the actual brazing.

Thousands of SIL-FOS and EASY-FLO users have worked out effective methods of taking full advantage of the fast brazing action of these low temperature silver alloys. Out of these methods has come a clear-cut *basic procedure* which can be readily adapted to obtain any required brazing production. Here are the simple basic steps to follow:

1. *Preplace the alloy* at the joints in wire, wire ring, washer or strip form, depending on the type of joint.
2. Use a *fast handling set-up* to keep parts moving steadily through cleaning, fluxing, assembling and heating operations.
3. Use a *fast heating method* — oxyacetylene torch, furnace, induction, gas-air, etc., preferably with the heating time and temperature under automatic control.

An example of the effective application of this procedure is illustrated—the brazing of adapters to hand grenade bodies. With a simple conveyor set-up and gas-air heating, a production of 660 brazed assemblies per hour is readily maintained.

## GET THE FULL STORY IN THESE TWO BULLETINS

*BULLETIN 12-A* tells you all about SIL-FOS and EASY-FLO and the reasons for their remarkable brazing speed, strength, reliability and economy. Also gives you a lot of valuable information on joint designs, heating methods, etc.

The *SILVER ALLOY BRAZING* reprint gives you the full story of the hand grenade job and describes a number of other jobs on which similar fast production methods were used.

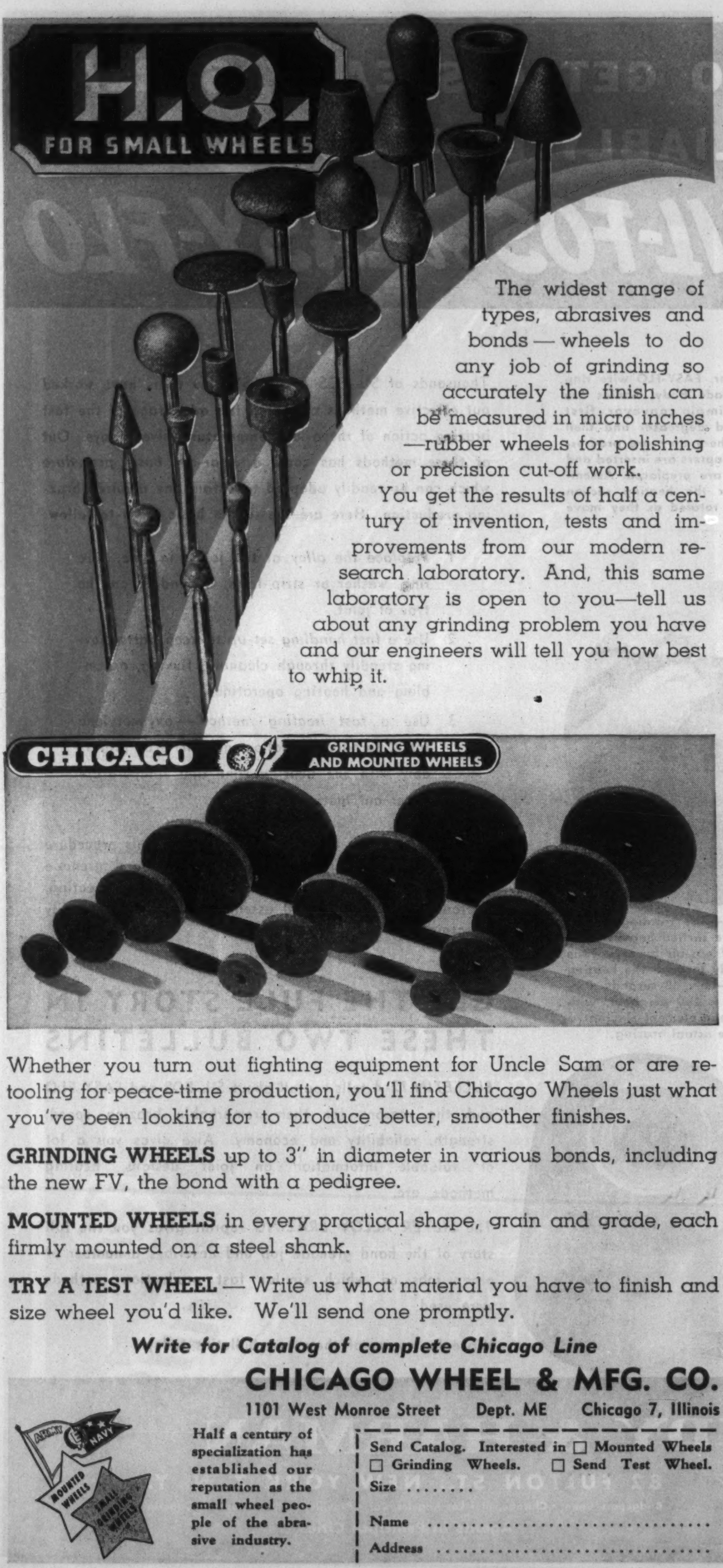
Write for copies of these two bulletins today.

**HANDY & HARMAN**

82 FULTON ST., NEW YORK 7, N. Y.

Bridgeport, Conn. • Chicago, Ill. • Los Angeles, Cal. • Providence, R. I. • Toronto, Canada

Agents in Principal Cities



**H.Q. FOR SMALL WHEELS**

The widest range of types, abrasives and bonds — wheels to do any job of grinding so accurately the finish can be measured in micro inches —rubber wheels for polishing or precision cut-off work.

You get the results of half a century of invention, tests and improvements from our modern research laboratory. And, this same laboratory is open to you—tell us about any grinding problem you have and our engineers will tell you how best to whip it.

**CHICAGO** GRINDING WHEELS AND MOUNTED WHEELS

Whether you turn out fighting equipment for Uncle Sam or are retooling for peace-time production, you'll find Chicago Wheels just what you've been looking for to produce better, smoother finishes.

**GRINDING WHEELS** up to 3" in diameter in various bonds, including the new FV, the bond with a pedigree.

**MOUNTED WHEELS** in every practical shape, grain and grade, each firmly mounted on a steel shank.

**TRY A TEST WHEEL** — Write us what material you have to finish and size wheel you'd like. We'll send one promptly.

***Write for Catalog of complete Chicago Line***

**CHICAGO WHEEL & MFG. CO.**

1101 West Monroe Street Dept. ME Chicago 7, Illinois

**Half a century of specialization has established our reputation as the small wheel people of the abrasive industry.**

Send Catalog. Interested in ☐ Mounted Wheels ☐ Grinding Wheels. ☐ Send Test Wheel.
Size ........
Name ........................................
Address ........................................

forced him to the floor, breaking the contact, despite great risk to himself.

Victory-speeding ideas of workers in the war plants of *Westinghouse* saved the war effort $1,765,059 in labor and material costs in 1944 by suggesting new and better ways of doing things. Suggestions totaled 38,709.

A $4,500,000 wire and cable plant is being constructed at Fort Wayne, Ind., by *Phelps Dodge Copper Products Corp.*, to be equipped for copper rod rolling, wire drawing, stranding and insulating. The company has also made an agreement with the D.P.C. to equip and operate a $5,851,733 brass rod mill at Hammond, Ind., with capacity of 20,000,000 lb. monthly. Other expansions are at Yonkers, N. Y., and Los Angeles.

*Walter Kidde & Co., Inc.*, Belleville, N. J., has bought the capital stock of the *Youngstown Miller Co., Inc.*, maker of plastic coaters and oil reclaimers.

The corporate name of Surface Combustion has been changed to *Surface Combustion Corp.*

The *International Nickel Co.* has created three new sections of the Development and Research Div.: Industrial Chemicals, headed by O. B. J. Fraser, Corrosion Engineering, with F. L. La Que in charge, and Iron and Non-Ferrous Casting, headed by Donald J. Reese.

The *Babcock & Wilcox Tube Co.*, Beaver Falls, Pa., the first to make stainless steel tubing in the United States, is expanding to make atomic hydrogen welded tubing and pipe. It is stated that some of the new stainless materials anticipated in post-war development will require processing methods at present considered unconventional.

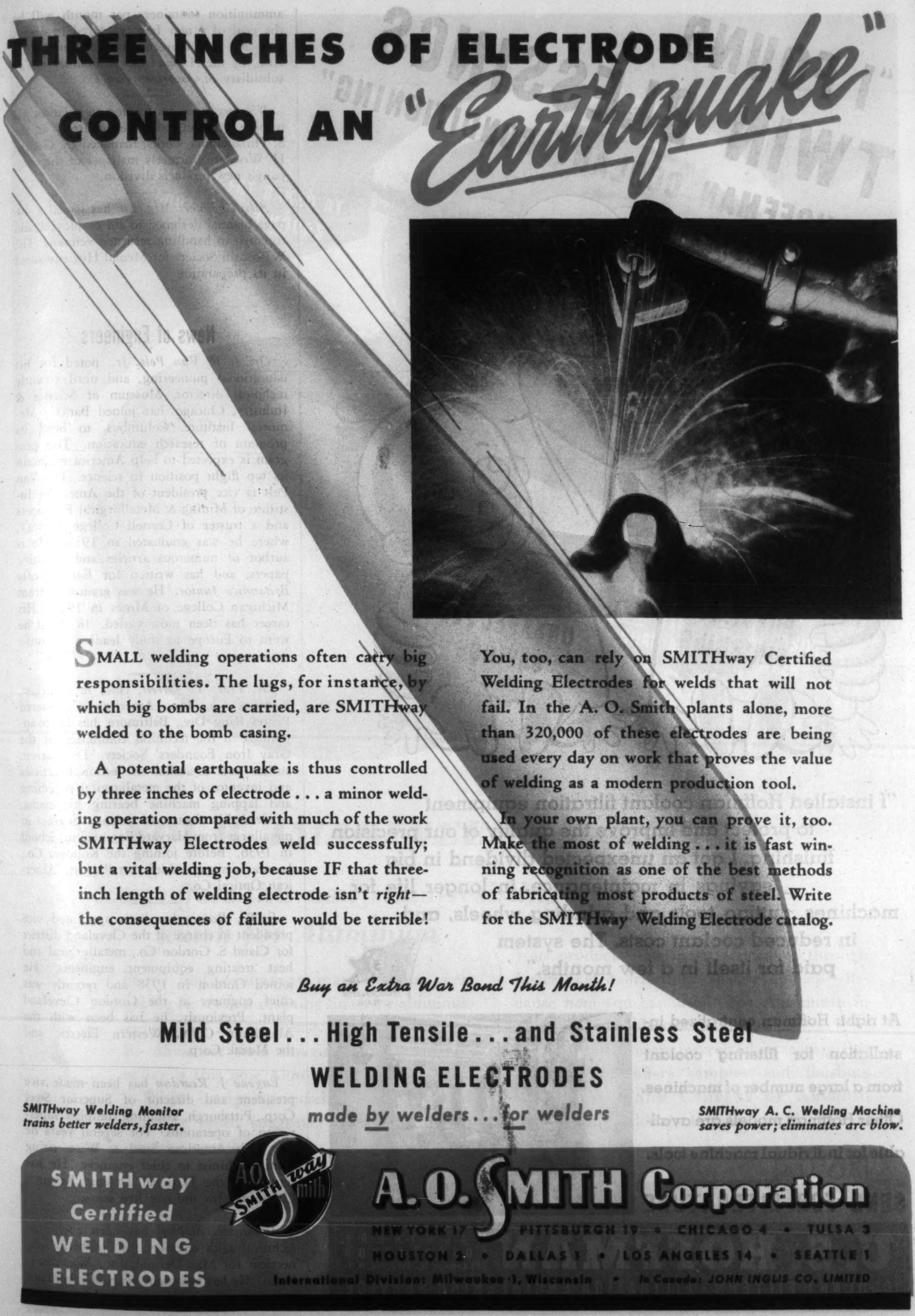
New centralized administrative offices of *Dresser Industries, Inc.*, formerly of Bradford, Pa., have been opened at 1130 Terminal Tower, Cleveland. The new offices will reduce executive travel time to the company's 18 plants. Unusual construction and lighting features add to working efficiency.

Negotiations for the purchase of the majority of the outstanding capital stock of the *Firth-Sterling Steel Co.*, McKeesport, Pa., by a group of private investors, headed by *Lehman Brothers*, New York, have been concluded. Production, distribution and research are to be expanded. The company is the second largest U. S. producer of sintered carbides.

The *Alexander Milburn Co.* of Baltimore, gas cutting, welding and spray gun apparatus, has been taken over by the newly-organized *Black Mfg. Co.* S. Duncan Black, Jr., president, is the son of the president of the *Black & Decker Co.*

Entrance of *Salkover Metal Processing* into the field of design and method consultation as to electric furnace copper brazing is announced.

Production of over 6,000,000 artillery



# THREE INCHES OF ELECTRODE CONTROL AN "*Earthquake*"

SMALL welding operations often carry big responsibilities. The lugs, for instance, by which big bombs are carried, are SMITHway welded to the bomb casing.

A potential earthquake is thus controlled by three inches of electrode . . . a minor welding operation compared with much of the work SMITHway Electrodes weld successfully; but a vital welding job, because IF that three-inch length of welding electrode isn't *right*—the consequences of failure would be terrible!

You, too, can rely on SMITHway Certified Welding Electrodes for welds that will not fail. In the A. O. Smith plants alone, more than 320,000 of these electrodes are being used every day on work that proves the value of welding as a modern production tool.

In your own plant, you can prove it, too. Make the most of welding . . . it is fast winning recognition as one of the best methods of fabricating most products of steel. Write for the SMITHway Welding Electrode catalog.

*Buy an Extra War Bond This Month!*

**Mild Steel . . . High Tensile . . . and Stainless Steel**

**WELDING ELECTRODES**

*made by welders . . . for welders*

***SMITHway Welding Monitor trains better welders, faster.***

***SMITHway A. C. Welding Machine saves power; eliminates arc blow.***

**SMITHway Certified WELDING ELECTRODES**

## A. O. SMITH Corporation

NEW YORK 17 • PITTSBURGH 19 • CHICAGO 4 • TULSA 3
HOUSTON 2 • DALLAS 1 • LOS ANGELES 14 • SEATTLE 1
International Division: Milwaukee 1, Wisconsin • In Canada: JOHN INGLIS CO. LIMITED

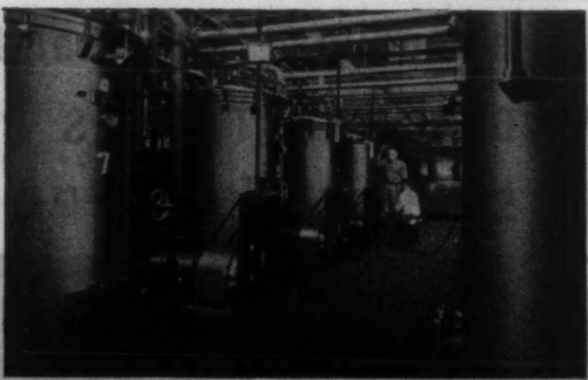
"I FOUND TWIN BLESSINGS —IN HOFFMAN COOLANT CONDITIONING"

PRECISION FINISHING
UNEXPECTED SAVINGS

**"I installed Hoffman coolant filtration equipment to protect and improve the quality of our precision finishing. I got an unexpected dividend in big savings in maintenance, in longer life for machines, cutting tools and grinding wheels, and in reduced coolant costs. The system paid for itself in a few months."**

POUGHKEEPSIE PLANT

**At right: Hoffman centralized installation for filtering coolant from a large number of machines. Other Hoffman models are available for individual machine tools.**



**SEND FOR LITERATURE**

**U. S. HOFFMAN** MACHINERY CORPORATION
223 Lamson St., Syracuse, N. Y.

COOLANT FILTERS • FILTRATION ENGINEERING SERVICE

ammunition containers per month will be the goal of a new factory placed in operation for the Government at Pine Bluff, Ark., by the *Ammunition Container Corp.*, subsidiary of *American Can Co.*

*Westinghouse* has formed an aviation gas turbine division, with headquarters at the S. Philadelphia works, managed by George H. Woodard, formerly manager of the company's new products division.

*Allis-Chalmers Mfg. Co.* has issued a 40-page manual designed to aid employees and foremen in handling returned veterans. The Wisconsin Society for Mental Hygiene aided in its preparation.

## News of Engineers

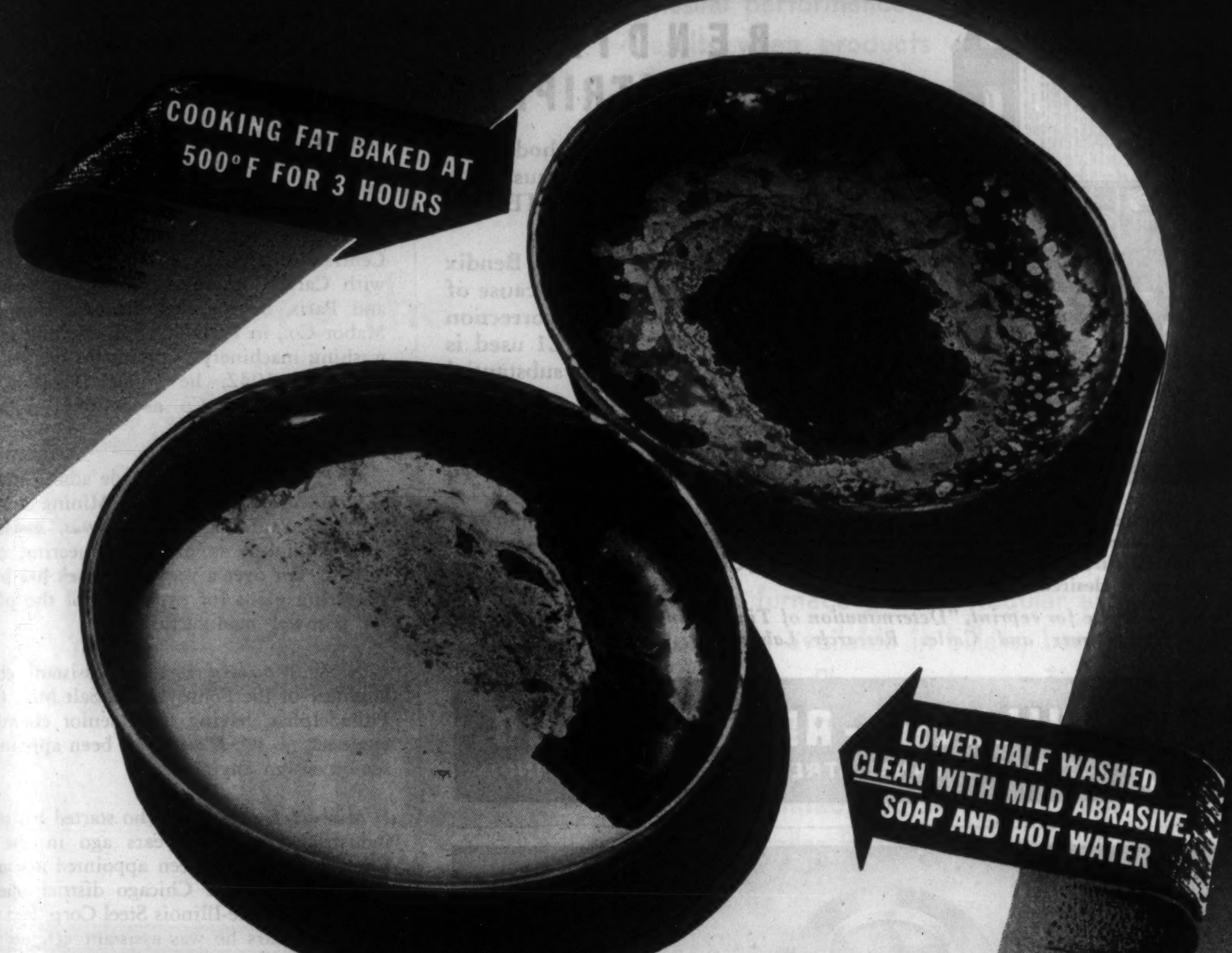
*Dr. J. R. Van Pelt, Jr.*, noted for his educational pioneering, and until recently technical director, Museum of Science & Industry, Chicago, has joined Battelle Memorial Institute, Columbus, to head its program of research education. The program is expected to help America maintain its top flight position in science. Dr. Van Pelt is vice president of the American Institute of Mining & Metallurgical Engineers and a trustee of Cornell College (Iowa), where he was graduated in 1918. He is author of numerous articles and scientific papers, and has written for *Encyclopedia Britannica Junior*. He was graduated from Michigan College of Mines in 1922. His career has been most varied. In 1930 he went to Europe to study leading scientific museums.

*Dr. Tracy C. Jarrett*, chief metallurgist, Koppers Co., Inc., American Hammered Piston Ring Div., Baltimore, has been appointed to the technical committee of the Gray Iron Founders' Society. Dr. Jarrett, author and co-author of technical articles and inventor of the metallurgical polishing and lapping machine bearing his name, received his doctor of science degree in metallurgy from Harvard Engineering School in 1936. Before joining the Koppers Co., he was assistant chief metallurgist, American Optical Co.

*E. W. Romig* has been appointed vice president in charge of the Cleveland district for Claud S. Gordon Co., metallurgical and heat treating equipment engineers. He joined Gordon in 1938 and recently was chief engineer at the Gordon Cleveland plant. Previously, he has been with the Aluminum Corp., Western Electric and the Muzak Corp.

*Eugene J. Reardon* has been made vice president and director of Superior Steel Corp., Pittsburgh, assuming complete supervision of operations. For several years he was with American Steel & Wire, rising from machinist to chief engineer. He has served on the National Defense Research Committee for the past five years.

*Arthur R. McNeil* has been appointed technical sales engineer for Southern Connecticut for Mac Dermid, Inc., Waterbury, Conn. He has had many years of experience in plating, polishing and finishing with


COOKING FAT BAKED AT 500°F FOR 3 HOURS
LOWER HALF WASHED CLEAN WITH MILD ABRASIVE, SOAP AND HOT WATER

# FOR YOUR *IMAGINEERS*

## *...Alcoa offers this new stain-resisting finish for Aluminum*

Stove and equipment manufacturers were asking for a stain-resisting finish for aluminum—for oven liners, grease pans and the like. So Alcoa set their Imagineers to work. The result is this new Alumilite* finish.

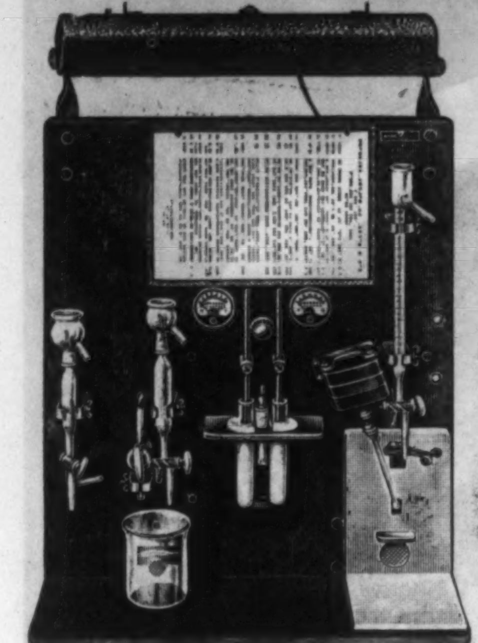
What intriguing possibilities this stain-resisting finish suggests! Added beauty for your products—increased efficiency through faster heat distribution—easier upkeep—because *now* you can use Alcoa Aluminum in so many new places.

To manufacturers interested in testing this finish, Alcoa offers samples and finishing service. ALUMINUM COMPANY OF AMERICA, 2162 Gulf Building, Pittsburgh 19, Penna.

**Registered trademark*

**ALCOA ALUMINUM**

200 Tin Plate Determinations per day!



can easily be handled by one operator

BENDIX ELECTRO-STRIPPER

Now replaces the Sellers method in tin plate determinations . . . because it is FASTER, MORE ACCURATE and MORE ECONOMICAL!

The original design of the Bendix Electro-Stripper eliminates the cause of errors in other methods. No correction factor is necessary! The HC1 used is 1 to 7 dilution, resulting in substantial savings.

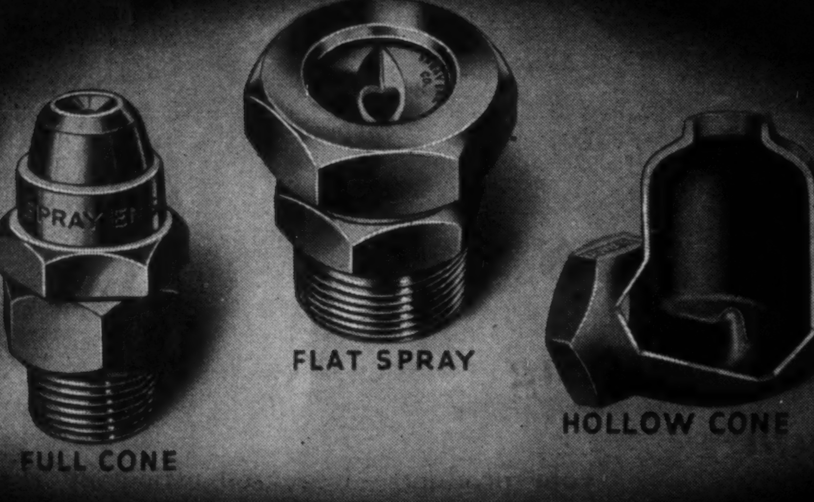
*Used by Carnegie Illinois, Youngstown Sheet and Tube, Weirton Steel, Bliss and Laughlin, Wheeling Steel, Continental Can, American Can Co., etc.*

No. 3516 Bendix Electro-Stripping Apparatus. Includes Stripper; Titration Assembly with motor for stirring; Automatic Pipette and support. With power pack to supply direct current. Attaches to 110 volt, 60 cycle A.C. line (or with 6-volt storage battery, if desired) . . . . . . . . . . $248.00

*Write for reprint, "Determination of Tin Coating Weights" by Bendix, Stammer and Carle. Research Laboratory, Continental Can Co.*

MA 5-45

WILKENS-ANDERSON CO.
111 NORTH CANAL STREET • CHICAGO, ILLINOIS



SPRACO NOZZLES

Write for NOZZLE CATALOG to
SPRAY ENGINEERING CO.
109 CENTRAL STREET • SOMERVILLE 45, MASS.

such companies as Underwood Elliott Fisher, Contract Plating Co., and Bridgeport Thermostat.

*C. M. Bovard* has been promoted from chief draftsman to design engineer of Cooper-Bessemer Corp. *Ralph H. Schlosser* has become chief draftsman.

*Marcel C. Boss* has been made chief engineer in charge of design and production of the Optimus Equipment Co., Matawan, N. J., maker of mechanical metal washing equipment. He was educated in the famous French engineering school, École Centrale de Paris. Formerly an engineer with Carrier Engineering Co., in London and Paris, he founded his own company, Mabor Co., in Paris in 1930, making metal washing machinery. Coming to the United States in 1942, he joined Hanson-Van Winkle-Munning Co. as engineer, joining Optimus in 1944.

*C. P. Pesek* has been made administrator of engineering of Minnesota Mining & Mfg. Co., St. Paul. *W. A. Thomas,* assistant chief engineer, is made engineering consultant. For over a year Mr. Pesek has been preparing plans for expansion of the plant for post-war manufacture.

*A. S. Woodard* is made assistant chief engineer of the Pennsylvania Salt Mfg. Co., Philadelphia, having been senior chemical engineer. *J. W. Dadley* has been appointed senior design engineer.

*Michael J. Devaney,* who started his steel industrial career 45 years ago in the S. Chicago plant, has been appointed assistant to the manager of Chicago district operations of Carnegie-Illinois Steel Corp. For the past four years he was assistant general superintendent of the plant. He is succeeded by *John H. Vohr,* assistant to the general superintendent. Mr. Devaney has had extensive open-hearth experience. Mr. Vohr has been with Inland Steel Co., Youngstown Sheet & Tube Co. and Granite City Steel Co.

*Dr. Norman A. Skow,* formerly of Bakelite Corp., has become director of research, Synthane Corp., Oaks, Pa. He will do research and development of Synthane plastics for technical applications.

*Walter H. Murphy* has been named shell production manager at the Victory yard, Electric Boat Co., Groton, Conn. He has had much experience in the manufacture of 105-mm. shells and in pre-war, in forge work.

*Carl C. Gohdel* has become manager of the special steels department at the Philadelphia plant of Joseph T. Ryerson & Son, Inc. He is well versed in alloy, stainless and tool steel.

---

*Leland Russell van Wert, Sc.D.,* consulting metallurgist, Leeds & Northrup Co., Philadelphia, died at the Pennsylvania hospital on March 26, at the age of 53. After graduating from Union College in 1916, he was a physical metallurgist with the Dorr Co. and metallurgical engineer with the Remington Arms Co. He taught metal-

The Watchful Eyes of Metallographers Assure the Uniformity of TIMKEN Alloy Steels

Faster production -- lower rejections -- unusual performance and dependability -- are the results when products are made of time-proven Timken Alloy Steels.

To assure the uniformity of Timken Alloy Steels they are subjected to many rigid checks. One of these -- metallography ascertains facts concerning the physical structure of steel and searches for hidden flaws. Others are used to maintain accurate chemical composition, grain size, hardenability, physical and mechanical properties. As a consequence you can be sure the Timken Alloy Steel you use will function satisfactorily in the service for which it was chosen.

Timken Alloy Steels are made in open hearth and electric furnace grades. Regular alloy and stainless steels are available in billets, bar stock and seamless tubing. Plan now to use Timken Alloy Steels. They will give your products extra sales appeal by providing them with consistent high strength and dependability. Steel and Tube Division, The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN

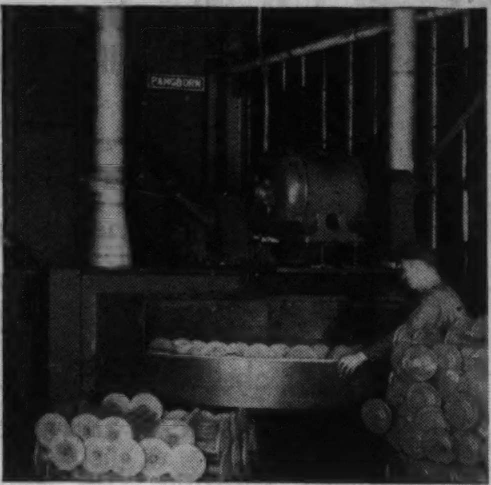
TRADE-MARK REG. U. S. PAT. OFF.

ALLOY STEELS

The Timken Roller Bearing Company Steel and Tube Division is a dependable source of supply for Alloy Steels, Seamless Steel Tubes for mechanical and pressure applications, Stainless Steels, and Graphitic Steels for tools and dies.

CLEANS FAST!

ROTOBLAST* BARREL



ROTOBLAST* TABLE

SPEED lowers cost—increases tonnage—saves abrasive and power

BLAST CLEANING played an important part in the successful production of bombs and shells and tanks and ships for this war. The main objective of the metal industry has been to *speed* production of *better* products. Pangborn engineers provided both Air and Airless equipment to do this job. Industry uses these modern machines to increase speed as much as 300 percent over previous records.

For post-war requirements, other considerations, not so essential as speed, will be of primary interest to businessmen who again will think in terms of costs and profit. Investigation will show that Pangborn Barrels and Tables and Special Machines clean more work per hour at less cost per ton; use less abrasive per ton of work cleaned because pneumatic and gravity operation, featured only by Pangborn, insures continuing re-use of steel shot or grit without waste until every particle is completely worn away; few operating parts and direct transmission of power insure lowest electrical consumption; and man-power is at minimum because one operator does all the work.

For detailed description and data—write for Bulletins.

**Trade mark of Pangborn Corporation*

PANGBORN

WORLD'S LARGEST MANUFACTURER OF DUST COLLECTING AND BLAST CLEANING EQUIPMENT

PANGBORN CORPORATION · HAGERSTOWN, MD.

lurgy at Harvard and Carnegie Tech. He joined the research department of Leeds & Northrup in 1937, and became chief of the research department's metallurgical section in 1939. He belonged to several technical societies.

---

*Prof. Alfred V. de Forest,* noted engineer and member of the Department of Mechanical Engineering at Massachusetts Institute of Technology, died April 5 at the age of 56. He was best known for his development of the Magnaflux test, a magnetic method of discovering defects in metals. From 1918 to 1928 he was research engineer of the American Chain Co., where he attained an outstanding reputation as a consulting engineer, specializing in the application of various special tests and inspection methods to metals. He was awarded many medals by engineering societies. For the last few years he did important war research. In early years he taught engineering at Princeton University.

## Briefs on Associations, Promotions and Education

For distinctive contributions in the field of cast metals, the American Foundrymen's Assn. recently awarded gold medals and honorary life memberships to five foundry field leaders. Robert E. Kennedy, secretary, received the Joseph S. Seaman gold medal "for outstanding meritorious service to all branches of the foundry industry." C. E. Sims won a gold medal for "contribution to the steel casting industry." Honorary life memberships went to M. J. Gregory, Rear Admiral A. H. Van Keuren, Ralph J. Tector, R. E. Kennedy and C. E. Sims.

*Dr. Zay Jeffries, General Electric Co., has won the annual powder metallurgy medal of Stevens Institute of Technology for "outstanding work in the field of powder metallurgy." The medal itself is made from powdered metals.*

At least 40 research projects, undertaken at the request of the Government to aid industry adopt more efficient production methods, have been carried out by the Manufacturing Engineering Committee of the American Society of Mechanical Engineers. Much of the committee work has dealt with dissemination of information about high-speed milling. Much research has aimed at improving and speeding up existing equipment without increasing manpower.

*A thousand dollars in prizes will be awarded by the Resistance Welder Manufacturers' Assn., 505 Arch St., Philadelphia 6, for papers on resistance welding, the contest closing July 31, 1945. A prize of $500 will go to the best paper from an industrial source, consulting engineer, government laboratory, etc., on design. Two prizes of $200 each will be awarded papers*

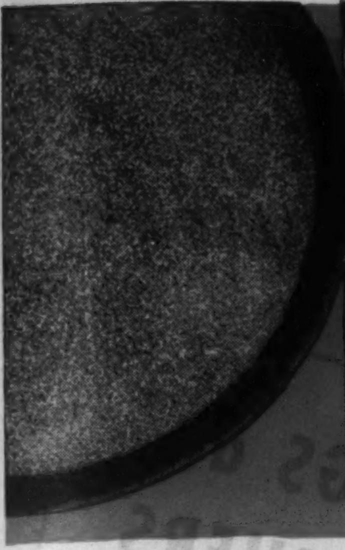


Fig. 1. *Macrostructure*—Dark circumferential area is the hardened portion of the steel.

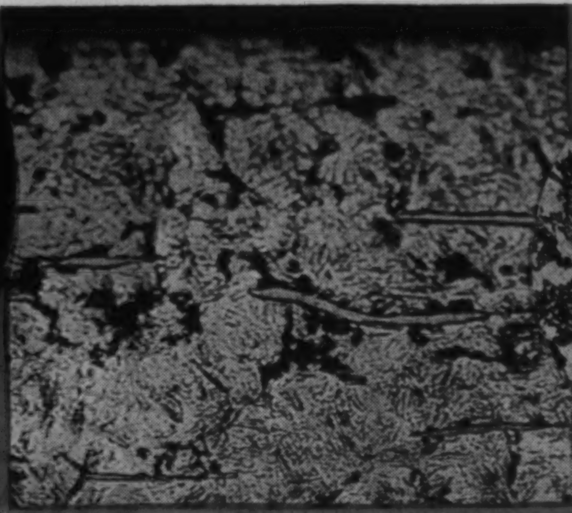


Fig. 2. *Surface of Shaft*—Medium-coarse grained martensite: dark areas of troostite. Manganese sulfide stringers.

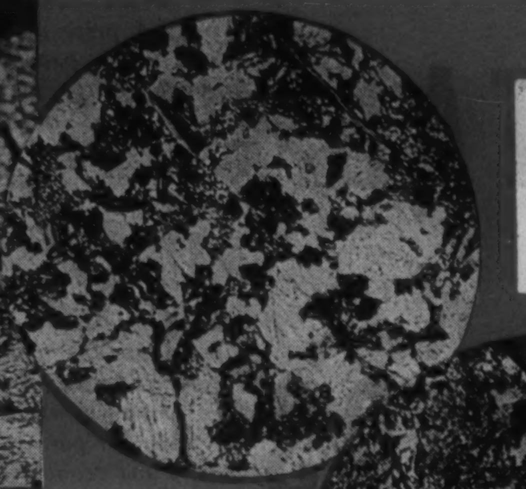


Fig. 3. *.060" Below Surface*—light areas of medium-coarse grained martensite and dark areas of troostite.

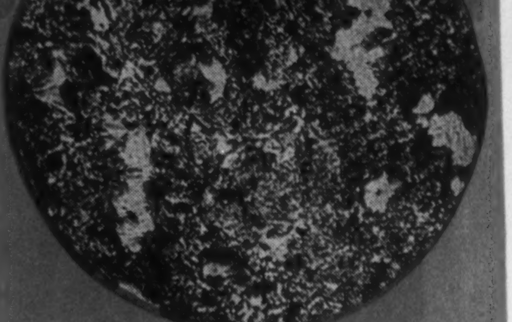


Fig. 4. *.112" Below Surface*—structure is troosto-sorbitic with patches of martensite. This area is in zone close to core structure.

# LEPEL *High Frequency* INDUCTION HEATING MAKES CONTINUOUS SURFACE HARDENING OF SHAFTING AND TUBING PRACTICAL......

Induction heating with the Lepel High Frequency Unit dispels the notion that very heavy and expensive equipment is necessary for continuous surface hardening of shafting and tubing.

● Lepel spark-gap-operated equipment, generating frequencies of 100,000 to 450,000 cycles, creates heat so rapidly that continuous progressive heating and quenching is practical with normal current input. Shafting or tubing up to 3" diameter can successfully be heat treated with a standard 30 KW unit.

● Slow rotation of shaft during heating and quenching develops highest uniformity consistent with chemistry of the steel.

● Heating is so rapid and the time at heat so short that even normal grain growth associated with conventional heat treating methods does not take place. This makes it possible to use ordinary carbon steels in many applications where alloys heretofore have been required.

● High frequency induction heating develops a super-hard skin which provides superior wearing qualities.

● The speed of heating and the short time at heat prevents surface decarburization and scaling. Ground shafting and tubing may be hardened without the need for finishing after quenching.

● Due to the short heating and quenching cycle, the core structure is unchanged and highest ductility is maintained.

● Depth of hardness can readily be controlled by adjusting the input power or varying the travel speed of the part through the heating coils.

● Distortion is minimized, regardless of the length of the part.

Any hardenable steel can be heat treated with equal assurance of satisfaction. The photomicrographs illustrate the results obtained with a steel of the following analysis:

| | |
|---|---|
| Carbon | .35/.45 |
| Manganese | 1.35/1.65 |
| Phosphorus | .045 max. |
| Sulphur | .20/.30 |

In the illustration below, a 2" shaft 17" long is being hardened by passing it progressively through the heating coil and quench ring. Horizontal travel is 2½ feet per minute and the shaft is rotated as it travels forward. Quenching temperature is 1500/1550° F with a water quench.

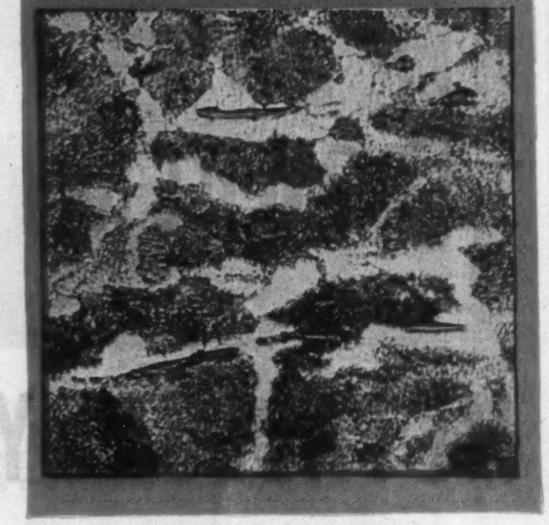


Fig. 5. *Core Structure* — medium-coarse grains of pearlite, lamellar pearlite and ferrite. Manganese sulfide stringers are uniformly distributed throughout. Structure is unchanged by hardening operation.

Fig. 1 shows the macroetched section of the shaft at approximately 1.5X magnification, indicating a penetration of 5/64". Only the surface yields the full hardness, Rockwell C60/C61, the Rockwell reading declining to C40 as the core is approached.

Figures 2, 3, 4 and 5 (500X magnification) show the grain structure at the surface, .060" and .112" below the surface and at the core respectively.

The same Lepel Unit can also be used for localized hardening, stress relieving, normalizing, brazing and soldering.

If you have a problem of surface hardening steel shafts or tubing of any length, Lepel engineers will be pleased to show you how you can not only secure better results, often with lower-priced steels, but also effect important economies in hardening cost and production time.

Lepel
High Frequency
INDUCTION HEATING UNITS

**LEPEL HIGH FREQUENCY LABORATORIES, INC.**

***PIONEERS IN INDUCTION HEATING***

***General Offices:* 39 West 60th Street, New York 23, N. Y.**

***Chicago Office:* 230 East Ohio Street, Chicago 11, Ill.**

METAL

POWDERS

FOR

POWDER

METALLURGY

POWDER
METALS and
ALLOYS, INC.

77 River Street
HOBOKEN, N. J.

Hudson Run Road
BARBERTON, O.

*on advancement and use of resistance welding. A prize of $100 will go to the best remaining paper falling in any of the above groups.*

Clem Stein, manager, industrial sales, International Derrick & Equipment Co., Columbus, has been made president of the American Hot Dip Galvanizers Assn.

*The National Foremen's Institute, Inc., has compiled a comprehensive opinion poll from 50,000 foremen of industry. It has compiled its findings under the title, "What Foremen Want to Know." Preference expressed for particular subjects rate: Business news and economic outlook, 27%; technical developments and new products, 24%; labor and employment news, 22%; international relations, 9%; political trends, 7%; military events, 6%.*

A "Reading List for Junior Engineers" has been compiled in pamphlet form by the Junior committee on Professional Training, Engineers' Council for Professional Development, 29 W. 39th St., New York 18. It covers natural science, philosophy, including religion, economics and sociology, psychology, business and industrial management, literature, including poetry, essays and fiction, history, biography, travel and the fine arts.

*An award program to encourage the preparation and publication of textbooks, one on machine design and another on structural design for fabrication by all processes, including welding, is announced by the James F. Lincoln Arc Welding Foundation, Cleveland. The prime effect of the plan will be to render a service to engineering colleges and to the industries that employ their graduates by making this pertinent and timely information more conveniently available and comprehensible. Awards are to be made in two classes: Machine Design and Structural Design, with awards in each of $5,000, $3,000 and $2,000.*

The Department of Mining & Metallurgical Research, University of Utah, Salt Lake City 1, is offering several research fellowships for the academic year, starting September, 1945, each carrying a stipend of $600. They are open to college graduates with the proper background in mathematics, chemistry and physics.

*Two technical films have been released by Bakelite Corp., 300 Madison Ave., New York 12: "Bakelite Plastics—Selecting the Right Thermosetting Molding Material" and "Bakelite Plastics—Product Design and Molding Technique for Thermosetting Plastics."*

The American Standards Assn. is starting to develop a series of American war standards for drawing and drafting room practice that will correlate the practices of the Army and Navy with those of industry. Typical subjects are: Abbreviations, methods of indicating and specifying threads, methods of lettering, drawing forms and sizes, and methods of numbering drawings.

*The Office of Alien Property Custodian offers about 45,000 seized enemy patents*

SILVER BRAZING
ALLOYS

RINGS and
WASHERS
for all
brazing jobs

ANY QUANTITY
ANY SHAPE
ANY SIZE

Also Strip, Coiled Wire, and Filings.

Available in standard alloys covered by Federal Government, Army, Navy, Air Corps and A.S.T.M. specifications.

For your post war products—investigate our special alloys described in booklet M-A sent on request.

Your inquiries invited

A.P.W. FLUX PASTES
Safe and convenient.
Excellent cleaning action.

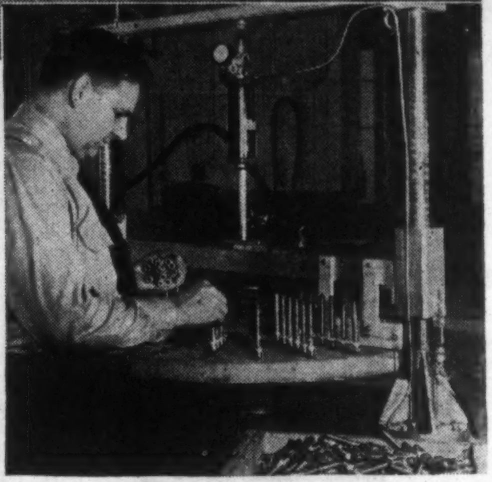
PRECIOUS METALS
APW
SINCE 1875

THE
AMERICAN
PLATINUM WORKS
N. J. R. R. AVE. AT OLIVER ST.
NEWARK 5, N. J.

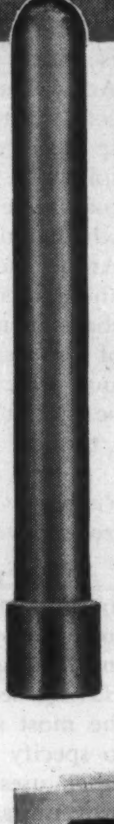
# INSIST ON PROOF BY TRIAL

## before you buy an Electronic Heater

**This is how Scientific Electric proved the value of electronic heating to the Progressive Welding Company of Norwalk, Connecticut . . .**



Above: This practical, automatic brazing turntable powered by a 40 KW. Scientific Electric heater speeded up production 700%—cut costs 87% and reduced rejects by 90%.

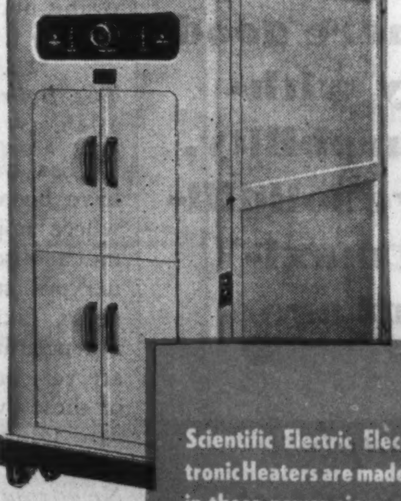


Left: Close-up of the finished two-piece tube assembly after being brazed by induction heating. Three complete brazing installations have been built for Progressive.

**GREAT improvements in product quality and remarkable savings in time and money are being achieved by means of electronic heating. Industrialists everywhere are now acclaiming its many advantages. But don't let your enthusiasm lead you to invest in an electronic heater before you have seen it perform the work you expect of it.**

**Another important point is this . . . in order to work at maximum efficiency and live up to its reputation for doing things better, faster and cheaper . . . electronic heating must be "tailored" to the job. That is why we never sell a Scientific Electric unit until it has been satisfactorily demonstrated. Regardless of the amount of time and effort required, our engineers will not release a single machine for sale until it has fulfilled every claim we make for it.**

**So here is a word of counsel . . . get plenty of advice before you buy. Consult with our recognized engineers who have pioneered in electronic heating since 1921 and, without obligation, they will demonstrate what electronic heating can do for you.**



Write for a free copy of our handbook . . . *The ABC of Electronic Heating* which contains an easily understood explanation of this new heating method.

40 KW INDUCTION HEATER

**Scientific Electric**

***Division of***

**"S" CORRUGATED QUENCHED GAP COMPANY**

**119 MONROE ST. GARFIELD, N. J.**

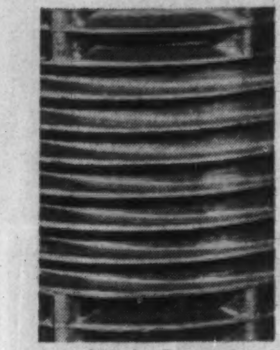
**Manufacturers of**

**Vacuum Tube and Spark Gap Converters Since 1921**

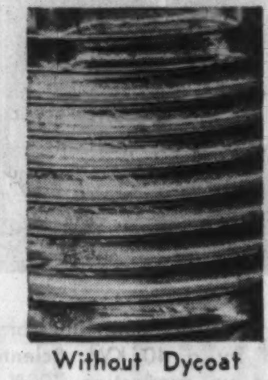
Scientific Electric Electronic Heaters are made in these power sizes... and a range of frequencies up to 300 Megacycles depending upon power requirements.

| | |
|---|---|
| 3 KW | 18 KW |
| 5 KW | 25 KW |
| 7½ KW | 40 KW |
| 8 KW | 60 KW |
| 10 KW | 80 KW |
| 12½ KW | 100 KW |
| 15 KW | 250 KW |

FOSECO
DYCOATS
FOR BETTER
*permanent*
MOLD CASTINGS



With Dycoat



Without Dycoat

**Highly efficient range for use in Aluminum, Magnesium, Zinc, Brasses and Aluminum Bronze where good finish, easy withdrawal, durability, progressive solidification and maximum output are required.**

*Write for samples, make your own test.*

**FOUNDRY SERVICES, INC.**
280 Madison Avenue
New York, N. Y.

*to United States citizens for an administrative fee of $15 per patent. The patents have been divided into 312 general groups.*

Through the formation of a $2,000,000 corporation uniting their efforts, electronic scientists of International Telephone & Telegraph Corp. will be grouped in a worldwide organization, with headquarters in the United States. The purpose will be to exchange inventions and provide closer coordination in electronics, radio, television, communications arts and aerial navigation.

## House Organ Notes

*Better Castings,* Niagara Falls Smelting & Refining Corp., April, 1945.

"Last year, and every year during this war, the coal miners have gone on strike. Last year children suffered with the cold even in their homes. These difficulties are caused by one man, John L. Lewis. He apparently is more powerful than the OPA, WPB, Army, Navy or the Government. Now the coal shortage is acute. We see the strange spectacle of the Government of the U. S. solemnly preparing to poll John L. Lewis' coal miners, under its official auspices, on whether they want to cripple the American Army and Navy with a strike. Mothers and fathers of the boys on the battlefront shall be taxed $300,000 to meet the cost of the poll. Has America gone nuts? In any other country on earth Lewis would be shot at sunrise for even whispering such a thing!"

*Report to Employees for 1944,* Rustless Iron & Steel Corp.

"This war has introduced 15 million fighting men to the advantages of stainless steels through their sturdy, corrosion-resisting mess gear, field kitchens and gun parts. Having seen its grand performance under the most severe conditions, they are likely to specify it for their homes, kitchens and other uses in civilian life. The war has proven stainless practical and desirable for hundreds of new uses. Thousands of processing and fabricating plants know how to handle it and appreciate its advantages."

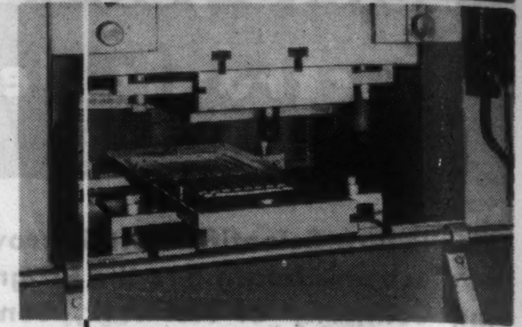
*The Bellringer,* Bell Aircraft Corp., April 1945.

"Ear wardens," made of pliable plastic, have been fitted on 2000 workers at Bell where noise was so terrific that it caused much discomfort, such as headaches and nervous strain. The "wardens" strain the noise, taking out the undesirable sounds, but permitting ordinary conversation. Users are very enthusiastic. One of the developers of these "wardens" is Dr. E. S. Russel, Harvard University.

*Newsfront,* Westinghouse Editorial Service, April, 1945.

This is a new publication, a 4-page report, printed in two colors and illustrated with drawings and photos. It contains short articles describing the latest achievements by the company in scientific research, engineering and production. One of the stories is on a new application of the Precipitron

Drawing and forming refrigerator parts, using Strenes metal dies.



**STRENES,**
**THE ONE DIE METAL THAT NEVER VARIES**

Why . . . because there is only one source . . . The Advance Foundry Co., Dayton, Ohio, where Strenes metal is poured by the very experts who originally developed it. Hence it has a uniform metallurgical structure after each and every melt. There are no licensee foundries.

Drawing and forming dies made from "Strenes" cuts machining time 35 to 50% because they are cast to shape, usually to 1/16". They deliver several times the usual number of stampings between redressings.

Used by practically all builders of cars, trucks, tractors, farm implements, refrigerators, stoves, grave vaults, etc. because of these distinct advantages. Names on request. No charge for first (get acquainted) casting if not satisfactory.

The
**ADVANCE FOUNDRY COMPANY**
100 PARNELL ST. DAYTON 3, OHIO

Strenes
METAL
FOR DRAWING AND FORMING DIES

# 100% QUALITY CONTROL

with the

DuMONT *Cyclograph*

Sorting under-annealed malleable castings from satisfactory castings.

Sorting bolts, screws, nuts, etc., according to analysis and heat-treatment.

100% inspection of bar stock for specified grades, prior to costly forging and machining operations.

Control of a process at each step if desired, so that manufacture can be stopped as soon as the process varies enough so that unsatisfactory pieces are being produced.

DuMONT
Cyclograph

Comparisons of grain size in non-ferrous metals.

Checking pieces for uniformity of case depth.

Segregation of finished parts according to level of internal stresses.

Checking and sorting pieces according to cladding thickness.

Checking and sorting ferrous and non-ferrous metal parts, according to structure and analysis.

Non-destructive inspection of metal stock for uniform machinability in automatic production equipment.

➡ **Write for Literature...**

© ALLEN B. DUMONT LABORATORIES, INC.

**DUMONT** *Precision Electronics & Television*

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: WESPEXLIN, NEW YORK

IN CANADA: CYCLOGRAPH SERVICES, LTD. 12 JORDAN STREET, TORONTO, ONTARIO

CANADA CALLING

**Do Canadian and other British Empire Postwar Markets interest ycu?**

One of Canada's largest industries producing steel and a wide range of finished steel products from ore to finished article is open to discuss additional products for postwar production.

Strong financial position and firmly established sales organization extending to all British Empire markets, manufacturing facilities in addition to primary steel production include rolling equipment for plates, sheets, bars and wire rods; finishing equipment for wire and wire products, bolt and screw products; bar mill products and the full gamut of steel mill production.

Will consider production on a royalty basis or straight purchase of ideas showing evidence of filling market needs through large quantity production.

Address Dept. D P.O. Box 170,
Station B, Montreal, Canada.

air-cleaner for the removal of fly-ash, which usually escapes from the smoke stack of a power plant and settles on hundreds of adjoining acres.

*Bendix Radio Engineer,* Bendix Aviation Corp., Vol. 1, No. 4, 1945.

Under the heading of "The Ubiquitous Walkie-Talkie" we read: "Train crews want walkie-talkies for their own mysterious purposes; farmers' wives ask when they can broadcast dinner call to the men instead of waiting or screaming. Now, elephants wired for sound carry rescue crews to crash-landed planes in jungles. Only adventure occurred when a radio-equipped elephant, charged by an intrepid rhinoceros, trumpeted an impromptu program into the transmitter abroad and scared the daylights out of his passengers and the listening audience."

*Process Industries Quarterly,* International Nickel Co., Inc., Vol. 8, No. 3.

"In the course of time all things in Nature return to the basic form or substance out of which they were created. Metals suffer attack by chemical forces and gradually revert to the natural form in which they are found in their ores. Corrosion costs American industry an estimated $1,000,000,000 annually. Some of corrosion's perculiar manifestations are still to be explained. But the confusion and misunderstanding of many years have been swept away and replaced by the knowledge that already enables us to understand many oddities of galvanic effects or to account for the puzzling symptoms of cell corrosion. From 20 years' study 'Inco' has published a tract, 'Corrosion.' Tables list nearly 500 corrosives where some nickel or alloy has been successfully used."

*Vancoram Review,* Vanadium Corp. of America, Winter, 1944-45.

"With this issue V. C. of A. dedicates its publication as a practical, impartial aid to the continued advancement and progress of alloys, metals and allied chemical compounds. It is to be published four times each year."

•

*The Parkerizer,* Parker Rust-Proof Co., Feb., 1945.

"The 'hissing blade' as a fighting tool has been out of style for many years. The Imperial Knife Co., Providence, produces 30% of the trench knives bought by the Army. They are both lethal and utilitarian. Besides fitting over the muzzle of a carbine rifle as bayonet, they open cans, pull nails, whittle wood and do many other odd jobs—and still retain their keenness. Made of finely tempered steel, they are formed, ground, heat treated and honed to a razor-like edge. After a final polishing, the blades are Parkerized to resist corrosion. This also removes the gleam or glisten that might attract the enemy. The blades are provided with a handle composed of rings of leather tightly pressed together on the shaft. The leather handle is ground to a shape that fits the hand, and is painted."

---

**PRECISION CASTING EQUIPMENT AND SUPPLIES**

*For Complete Installations*
*Lost Wax—Investment Molding Process*

•

CENTRIFUGAL CASTING MACHINES
METAL MOLD EQUIPMENT
WAX INJECTION MACHINES
VACUUM PUMP UNITS
WAX ELIMINATOR OVENS
FURNACES — GAS FIRED & INDUCTION
INVESTMENTS — WAXES — CRUCIBLES
AND ALL RELATED SUPPLIES

•

**ALEXANDER SAUNDERS & CO.**
*Successor to J. Goebel & Co. — Est. 1865*
95 BEDFORD ST., NEW YORK CITY 14

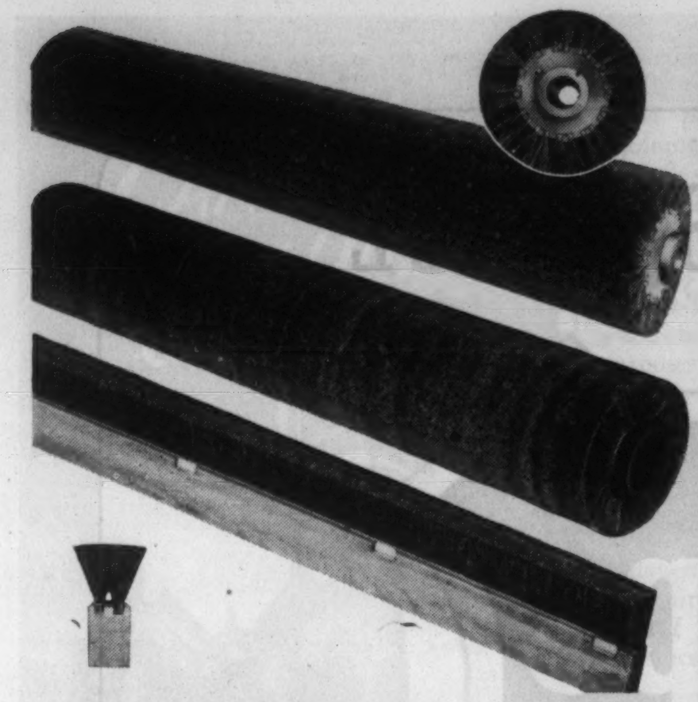
SYMBOL OF SERVICE

Phillips
BUTANE
PROPANE

We invite you to consider Phillips Propane and Butane as the most successful fuels for your heating operations. These "natural gases" are readily adapted to simple automatic control, provide a uniform heat, and are free from impurities likely to contaminate the process and are competitive with other low-cost fuels. Why not provide yourself with your own "natural gas" system which has proved its merit for 18 years. Phillips engineers will gladly advise you on problems involving propane and butane.

**PHILLIPS PETROLEUM COMPANY**
PHILGAS DIVISION
**BARTLESVILLE, OKLAHOMA**
**Branch Offices in NEW YORK, CHICAGO, PHILADELPHIA, MILWAUKEE, DETROIT, ST. LOUIS, SHREVEPORT, LA., AMARILLO, TEX., HIBBING, MINN.**

THE WORLD'S LARGEST MARKETER OF LIQUEFIED PETROLEUM GAS



FULLERGRIPT METAL FINISHING AND SCRUBBING BRUSHES

are designed and built for the job to be done. They contain more brush material than other construction—giving a better brushing action and a longer brush life.

Send blue prints and specifications, and place a trial order to be convinced.

**THE FULLER BRUSH COMPANY**
INDUSTRIAL DIVISION, 3686 MAIN STREET, HARTFORD 2, CONN.

Millions OF METAL POWDER PARTS NOW ACCURATELY PRODUCED ON THE NEW

KUX PRESS
FOR METAL POWDER PARTS

● Completely new patented design features now permit the manufacture of odd shapes of parts with complicated, cored holes, protruding lugs and various sectional thicknesses to micrometer accuracy. The formed pieces are made at speeds of up to 25 pieces a minute with uniform structural density throughout. Completely automatic in operation and applying up to 50 tons total pressure, Model No. 74 will produce parts up to 5" maximum diameter and has a powder cell, or die fill of 5½".

WRITE TO DEPT. MA FOR CATALOG or DEMONSTRATION

Many installations of as many as 25 machines in a single plant prove the superiority of Kux presses.

**Kux MACHINE COMPANY**
3924-44 W. HARRISON ST.
CHICAGO 24, ILL.

Model 74

King, Andrew ........ 1506
Kirk & Blum Manufacturing Co. ........ 1264
*Agency*—S. C. Baer Company
Kuhlman Electric Co. ........ 1400
*Agency*—Seeman & Peters, Inc.
Kux Machine Co. ........ 1488
*Agency*—Kuttner & Kuttner

Lake Erie Engineering Corp. ........ 1284
*Agency*—Addison Vars Co.
Lakeside Steel Improvement Co. ........ 1426
*Agency*—Brad-Wright-Smith Advertising, Inc.
Latrobe Electric Steel Co. ........ 1285
*Agency*—Advertising Agency of William Cohen
Lea Manufacturing Co. ........ 1452
*Agency*—Sanger-Funnell, Inc.
Leeds & Northrup Co. ........ 1296
Lepel High Frequency Laboratories, Inc. ........ 1481
*Agency*—G. M. Basford Co.
Lindberg Engineering Co. ........ 1425
*Agency*—M. Glen Miller
Lithaloys Co. ........ 1401
*Agency*—Sanger-Funnell, Inc.

Mac Dermid, Inc. ........ 1414
*Agency*—Philips Webb Upham & Co.
Machlett Laboratories Inc. ........ 1489
*Agency*—St. Georges & Keyes, Inc.
Mallory, P. R., & Co., Inc. ........ 1286
*Agency*—Aitkin-Kynett Co.
Mc Graw-Hill Book Co., Inc. ........ 1508
Mc Kay Co. ........ 1248, 1249
*Agency*—Smith, Taylor & Jenkins, Inc.
Meehanite Research Institute ........ 1231
Metal & Thermit Corp. ........ 1365
*Agency*—Hazard Advertising Co.
Metal Hydrides, Inc. ........ 1376
Metalloy Products Co. ........ 1506
Michigan Smelting and Refining Division ........ 1399
*Agency*—Zimmer-Keller, Inc.
Michigan Steel Casting Co. ........ 1280
*Agency*—L. Charles Lussier, Inc.
Mid-Continent Metal Products Co. ........ 1516
*Agency*—Perrin-Paus Co.
Midvale Co. ........ 1287
*Agency*—Lewis & Gilman
Mitchell-Bradford Chemical Co. ........ 1233
*Agency*—Claude Schaffner Advertising Agency
Modern Plastics Corp. ........ 1283
*Agency*—Paxson Advertising
Molybdenum Corp. of America ........ 1252
*Agency*—Smith, Taylor & Jenkins, Inc.
Monsanto Chemical Co., Plastics Division ........ 1272
*Agency*—Gardner Advertising Co.
Mt. Vernon Die Casting Corp. ........ 1490
*Agency*—United Advertising Agency

National Bearing Metals Corp. ........ 1356
*Agency*—H. George Bloch Advertising Agency
National Machine Gas Burners Div. ........ 1516
*Agency*—Perrin-Paus Co.
National Smelting Co. ........ 1509
*Agency*—Bayless-Kerr Co.
National Steel Corp. ........ 1277, 1455
*Agency*—Ketchum, MacLeod & Grove, Inc.
Nelson Specialty Welding Equipment Corp. ........ 1238, 1239
New Jersey Zinc Corp. ........ 1385
New Products Corp. ........ 1283
*Agency*—Paxson Advertising
Niagara Falls Smelting & Refining Corp. ........ 1501
Nitralloy Corp. ........ 1507
*Agency*—O. S. Tyson & Co., Inc.
North American Philips Co., Inc. ........ 1244, 1245
*Agency*—Erwin, Wasey & Co., Inc.

Norton Co. ........ 1278
*Agency*—John W. Odlin Co., Inc.
Nox-Rust Corp. ........ 1378
*Agency*—William Hoffman & Associates

Oakite Products, Inc. ........ 1428
*Agency*—Rickard & Co., Inc.
Ohio Crankshaft Co. ........ 1513
*Agency*—Griswold-Eshleman Co.
Ohio Steel Foundry Co. ........ 1521
*Agency*—Kircher, Lytle, Helton & Collett, Inc.
Oiljak Manufacturing Co., Inc. ........ 1386
*Agency*—Gotham Advertising Co., Inc.
Olin Industries, Inc. ........ 1281
*Agency*—D'Arcy Advertising Co.
Optimus Detergents Co. ........ 1468
*Agency*—A. W. Lewin Co.

Page Steel & Wire Div. ........ 1292
*Agency*—Reincke-Ellis-Younggreen & Finn, Inc.
Pangborn Corp. ........ 1480
Park Chemical Co. ........ 1471
*Agency*—Marvin Hahn
Patterson Foundry & Machine Co. ........ 1226
*Agency*—Walker & Downing
Pennsylvania Salt Mfg. Co. ........ 1251, 1413
*Agency*—Geare-Marston, Inc.
Permo, Inc. ........ 1502
*Agency*—William Hoffman & Associate
Phillips Petroleum Co. ........ 1487
*Agency*—Lambert & Feasley, Inc.
Phoenix Manufacturing Co. ........ 1276
*Agency*—Almon Brooks Wilder, Inc.
Physicists Research Co. ........ 1434
Picker X-Ray Corp. ........ 1271
Pittsburgh Lectrodryer Corp. ........ 1500
*Agency*—Fuller & Smith & Ross, Inc.
Pittsburgh Steel Co. ........ 1256
*Agency*—Smith, Taylor & Jenkins, Inc.
Powder Metals & Alloys, Inc. ........ 1482
Products Manufacturing Co. ........ 1504
*Agency*—Paulson-Gerlach & Associates, Inc.

Reduction & Refining Co. ........ 1374
*Agency*—G. Wilfred Wright Agency
Reinhold Publishing Corp. ........ 1514, 1522, 1524, 1530
Republic Steel Corp. ........ 1288
*Agency*—Meldrum & Fewsmith, Inc.
Revere Copper and Brass Inc. ........ 1351
*Agency*—St. Georges & Keyes, Inc.
Reynolds Metals Co. ........ 1459
*Agency*—J. Walter Thompson Co.
Rhoades, R. W., Metaline Co., Inc. ........ 1502
*Agency*—Alfred Fischer
Riehle Testing Machine Div. ........ 1431
*Agency*—L. W. Ramsey Co.
Roots-Connersville Blower Corp. ........ 1412
*Agency*—Morgan Advertising Co.
R-S Products Corp. ........ 1464
*Agency*—McLain Organization, Inc.
Ryerson, Joseph T., & Son, Inc. ........ 1298
*Agency*—Aubrey, Moore & Wallace, Inc.

St. Joseph Lead Co. ........ 1379
*Agency*—Walter Taegen
Salem Engineering Co. ........ 1497
*Agency*—Meek & Thomas, Inc.
Sargent, E. H., & Co. ........ 1450
*Agency*—Kreicker & Meloan, Inc.
Saunders, Alexander, & Co. ........ 1486
Schloemann Engineering Corp. ........ 1420
*Agency*—Sykes Advertising Agency
Sciaky Bros. ........ 1407
Scientific Electric Division "S" Corrugated Quenched Cap Co. ........ 1483
*Agency*—A. W. Lewin Co., Inc.
Scott Testers, Inc. ........ 1432
*Agency*—Richard Thorndike
Sinclair Refining Co. ........ 1294
*Agency*—Hixson-O'Donnell Advertising, Inc.

Smith, A. O. Corp. ........ 1475
*Agency*—Henri, Hurst & McDonald, Inc
Solar Aircraft Co. ........ 1511
*Agency*—Logan & Arnold
Special Chemicals Corp. ........ 1426
*Agency*—George Homer Martin Advertising
Spencer Turbine Co. ........ 1289
*Agency*—W. L. Towne
Spray Engineering Co. ........ 1478
*Agency*—Larcom Randall Advertising Agency
Stainless Surface Hardening Co. ........ 1360
*Agency*—John Mather Lupton Co.
Standard Steel Works Division ........ 1259
*Agency*—Ketchum, MacLeod & Grove, Inc
Sterling Alloys, Inc. ........ 1424
*Agency*—Cory Snow, Inc.
Stokes, F. J., Machine Co. ........ 1520
*Agency*—McLain Organization, Inc.
Superior Bearing Bronze Co., Inc. ........ 1457
*Agency*—Powerad Co.
Superior Tube Co. ........ 1447
*Agency*—Renner Advertisers
Swedish Crucible Steel Co. ........ 1295
*Agency*—Gerrish Albert

Taylor, Chas., Sons Co. ........ 1258
*Agency*—Strauchen & McKim
Thermal Syndicate, Ltd. ........ 1382
Timken Roller Bearing Co., Steel & Tube Division ........ 1479
Titanium Alloy Manufacturing Co. ........ 1368, 1369
*Agency*—Addison Vars Co.
Tube Turns, Inc. ........ 1440
*Agency*—Roche, Williams & Cleary, Inc
Turco Products, Inc. ........ 1499
*Agency*—Riordan & Messler

Union Carbide and Carbon Corp. ........ 1250, 1265, 1267
United Engineering & Foundry Co. ........ 1527
*Agency*—Smith, Taylor & Jenkins, Inc.
U. S. Hoffman Machinery Corp. ........ 1476
U. S. Reduction Co. ........ 1469
*Agency*—Goldman & Gross
U. S. Steel Corp. ........ 1508
*Agency*—Batten, Barton, Durstine & Osborn, Inc.
U. S. Steel Export Co. ........ 1508
*Agency*—Batten, Barton, Durstine & Osborn, Inc.
U. S. Stoneware Co. ........ 1232
*Agency*—Ralph Gross

Vanadium Corp. of America ........ 1503
*Agency*—Hazard Advertising Co.

Weirton Steel Co. ........ 1455
*Agency*—Ketchum, McLeod & Grove, Inc.
Western Brass Mills ........ 1281
*Agency*—D'Arcy Advertising Co.
Western Gold & Platinum Works ........ 1506
Westinghouse Elec. & Mfg. Co. ........ 3rd Cover
*Agency*—Fuller & Smith & Ross, Inc.
Wheelco Instruments Co. ........ 1500
*Agency*—Z. H. Mischka Co.
Wilkens-Anderson Co. ........ 1478
*Agency*—Root-Mandabach Advertising Agency
Wilson, H. A., Co. ........ 1512
*Agency*—Charles Dallas Reach Co.
Wilson Mechanical Instrument Co. ........ 1436
Wolfe-Kote Co. ........ 1514
Worcester Pressed Steel Co. ........ 1393
*Agency*—Sutherland-Abbott
Wrigley, Wm. Jr., Co. ........ 1496
*Agency*—Ruthrauff & Ryan, Inc.
Wyman-Gordon Co. ........ 1268
*Agency*—John W. Odlin Co., Inc.

Youngstown Sheet and Tube Co. ........ 1531
*Agency*—Griswold, Eshleman Co.

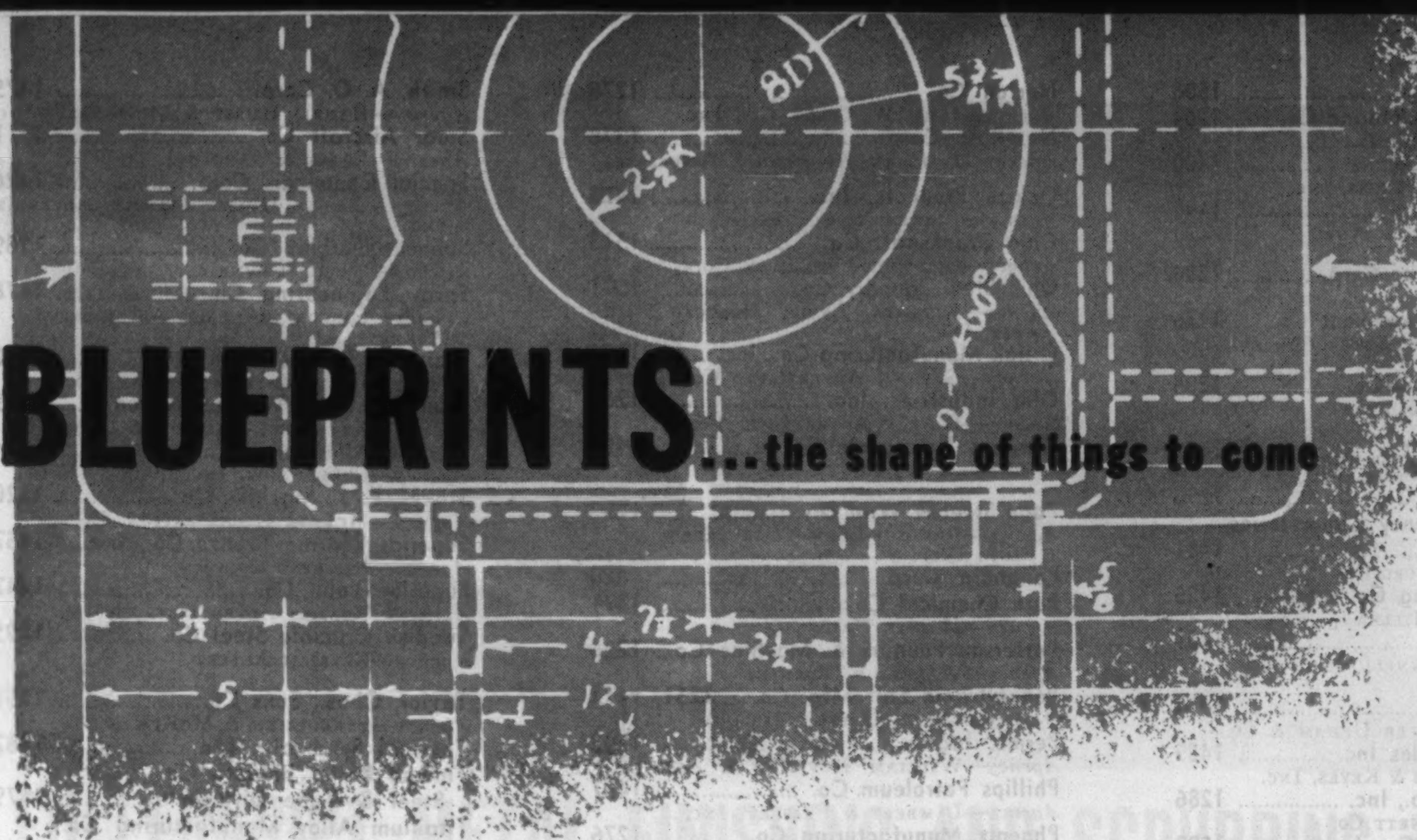
William P. Winsor, *Vice President and Business Manager*
*Advertising and Executive Offices: 330 West 42nd St., New York 18, N.Y.*

★

Member Audit Bureau of Circulations

A. E. Fountain, *District Manager, 330 West 42nd St., New York 18, N.Y.*
Fred Ullberg, Jr., *District Manager, 12 South 12th St., Philadelphia 7, Pa.*
Maynard S. Kearney, *District Manager, 1133 Leader Bldg., Cleveland 14, O.*
J. H. Stonhouse, *District Manager, 310 South Michigan Ave., Chicago 4, Ill.*
Roy M. McDonald, Roy M. McDonald & Co., *564 Market St., San Francisco 4, Calif.*
Milo Pugh, Roy M. McDonald & Co., *541 South Spring St., Los Angeles 13, Calif.*

ABP



# BLUEPRINTS...the shape of things to come

## Magnesium to Protect Steel

A post-war use of magnesium that if adopted *could* consume some 60 million lbs. of the light metal per year has been suggested by a sound and sensible source within the industry. This use would be as cathodic protection of steel pipe lines in contact with earth or water, the magnesium functioning as an anode to divert electrolytic action from the steel and having (it is said) many advantages over other materials conventionally used for this protection. Unprotected pipe lines now last 3 to 5 years, cathodically-protected pipe indefinitely.

## A Glass for Hydrofluoric Acid

Glass's traditional nemesis, hydrofluoric acid, has now been challenged by a new glass (whose basis is phosphorous pentoxide instead of silica) developed to resist this chemical. Although the new glass is very slowly attacked by the acid, unlike silica glass it remains transparent and is suggested for use in sight glasses, gages, screens, goggles, etc. in contact with hydrofluoric acid gas or solution.

## Tin

A post-war plenitude of tin will find several new uses ready and waiting. Tinned cast iron will be more common because of processing advances; stronger, tougher and more ductile tin bronzes will be available; and "speculum" or white-bronze (copper-tin alloy) plating may revolutionize low-cost non-tarnishing tableware.

## Magnetic Tape Recording

War-boomed and certain to burst into the civilian consciousness in the post-war period is the Army's use of magnetic tape or wire sound recording in place of impressionable wax, plastic, glass or aluminum disks mechanically grooved. In the magnetic system a continuous wire of a suitable magnetic material (an alloy of iron, vanadium and cobalt, which can hold an enormous amount of permanent magnetism) picks up and retains the magnetic variations corresponding to the transmitted sounds and may be "played back" immediately and indefinitely. No needles, no scratch, no brittle disks. But be careful—an unexpected or unwanted external energization can "erase" the record in a flash, and forever!

## Silver Clad Steel

Add to the modern clad metals with bright possibilities for the future: A silver-clad steel used in chemical and petroleum industry equipment that will handle hydrofluoric acid in high-octane gas production and also resists chlorinated solvents. Silver-*clad* steel is superior (it is said) to silver-*lined* steel because the former has better heat conductivity.

## Motorcar Materials

According to a materials engineer of one large automobile manufacturer, there will be little change in the relative quantities of steel, iron, aluminum and magnesium used in post-war, as compared with pre-war, automobiles. We're betting on steel bodies for a long time, ourselves, but chassis design may change in favor of the light metals. And here's a distinct post-war possibility: solid stainless steel bumpers!

## The Silicones

Post-war materials and process engineers are sure to find myriad uses for those fabulous new materials, the silicones, which are a cross between glass and plastics in their chemical nature. They serve for insulating varnishes that are waterproof and stable at temperatures up to 350 F., and thermosetting types are under development for laminated materials; the liquid silicones have a nearly constant viscosity over wide temperature ranges, leading to uses in instrument damping systems, liquid-filled condensers, moisture-proofed ceramics, lubricants for molding, and impregnants for various purposes. Tests are now underway on their possibilities for molded mechanical parts and as corrosion-proof finishes for metals.

## Bridge Decks

Open-mesh steel decking for city and rural bridges may be standard bridge equipment in the post-war period. Less supporting steel is required and the ratio of live to dead weight is improved. One bridge whose concrete-and-brick floor weighed 160 lbs. per sq. ft. was modernized with an open-mesh decking that weighs 21-22 lbs. per sq. ft., including supporting sills.

## Cold-Treated Cutlery

We've probably published more feature articles on subzero treatments for metals than any other magazine, but here's a promising application that has just now come to light—the cold treatment of band-saw blades, bread-knife blades and even the ubiquitous razor blade, to improve their hardness and stability. Results are described as so good that growing post-war use is certain.

## Post-War Steaks

Although it has nothing to do with materials and methods, this item classes as a post-war feature of interest to all engineers, characteristically beef-eaters from way back. According to the WFA, post-war steaks (remember?) will be closer to perfection—thick, juicy, butter-soft—because of scientific distribution of the fat through the meat, the development of an "ideal animal" and the emphasis on grass feeding rather than cotton-seed or corn meal. And speaking of corn . . .